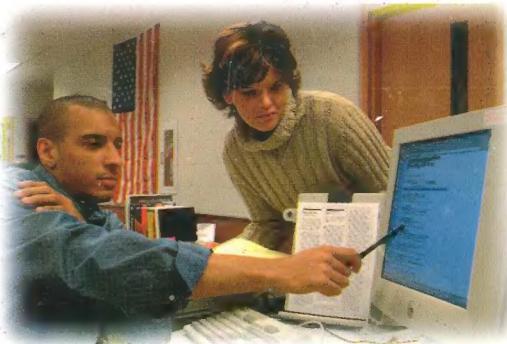
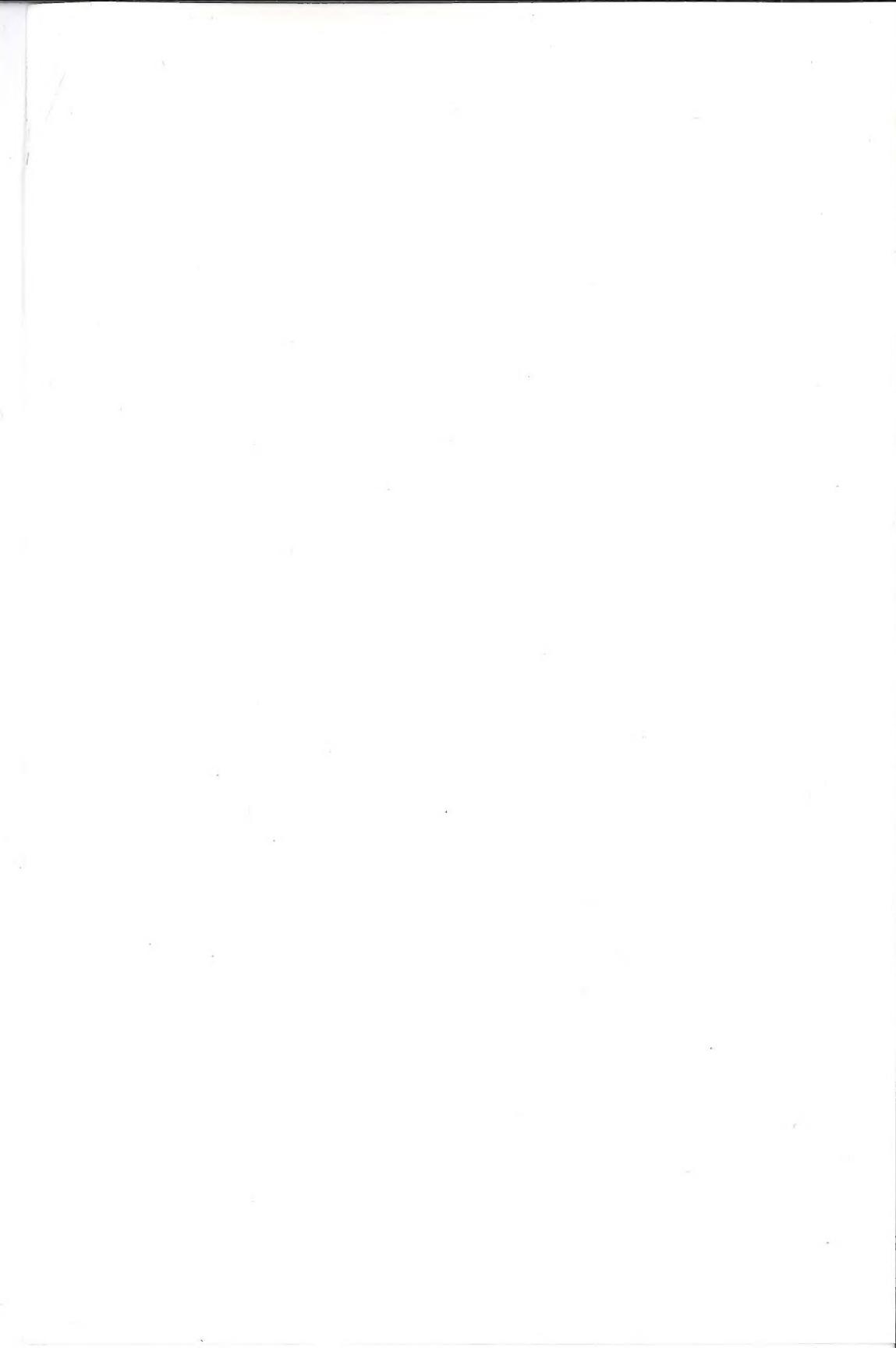


University of Wisconsin-Stout

# Journal of Student Research

Volume 1, May, 2002





University of Wisconsin-Stout  
Journal of Student  
Research

Volume 1, May, 2002



University of Wisconsin-Stout

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## **Foreword**

The University of Wisconsin-Stout is pleased to publish the first Journal of Student Research, May 1, 2002. To complement one of the goals of the e-scholar initiative, the Journal is being published in both electronic and print formats.

When initiating the Journal of Student Research, the Chancellor, Associate Vice Chancellor and I wanted a high quality work that focused on and recognized the research of graduate and undergraduate students at UW-Stout. This publication has met that standard.

In this Journal of Student Research it is a pleasure to present student research articles that have been supervised by faculty advisors and evaluated by faculty reviewers. While the first year has focused on the awareness of the opportunity for both faculty and students to be research-active, the future brings enhanced growth opportunities for student publication of their research.

UW-Stout, as a recipient of the 2001 Malcolm Baldrige Quality Award, continues to create and assess quality systems to deliver ever-reaching enhanced goals in teaching, learning and research in higher education.

Congratulations to the students whose research is published in the first UW-Stout Journal of Student Research.

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### **Style**

The goal of the UW-Stout Journal of Student Research is to recognize student achievement in research. Submissions are encouraged from every discipline represented on UW-Stout's campus. While articles may be submitted in a format appropriate to the discipline, the following elements are required: a title page, which includes the title, the researcher's name and major, the faculty research advisor and their department; an abstract, literature review and problem statement, methods, results, any relevant tables, pictures, graphs, etc. that will better illustrate the work and finally a discussion or conclusion section.

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The document must be submitted in Microsoft Word format. The maximum limit is 12 pages, in 12-point type for any submissions, including photos or illustrations. Photos must be saved as either .EPS or .TIFF formats to be most effective. Please note that any pictures given to us in a JPEG format will have poor resolution and will not properly represent your work.

Graphs, photos, and other visuals may be produced using the Adobe Photoshop or Adobe Illustrator in any version. There you can save photos and graphs as .TIFF or .EPS files very easily.

### **Human subjects**

UW-Stout requires anyone who is conducting research with human subjects or using data involving human subjects to obtain IRB approval before beginning the data collection process. Training, submission materials and information and contact information may be found at the Research Services web page at <http://www.uwstout.edu/rps/humnsbj.htm>. Research Services is located in 11 Harvey Hall.

### **Final draft**

Submissions must be in electronic format. Please insert specific subheadings in their proper position to provide reference for layout. The editors reserve the right to make editorial changes.

### **Review process**

Upon submission, the manuscript will be forwarded to a person on campus considered to be an expert in the research field. They will then make a recommendation to the editorial board as to whether or not the article is of professional quality and acceptable for publication. Once accepted, the editorial board will make final changes to the manuscript for the journal.

### **Selection Criteria**

Selection will be based on the research's ethical standard, professional quality and relevance to the field. The research must also fit the standards and mission of UW-Stout.

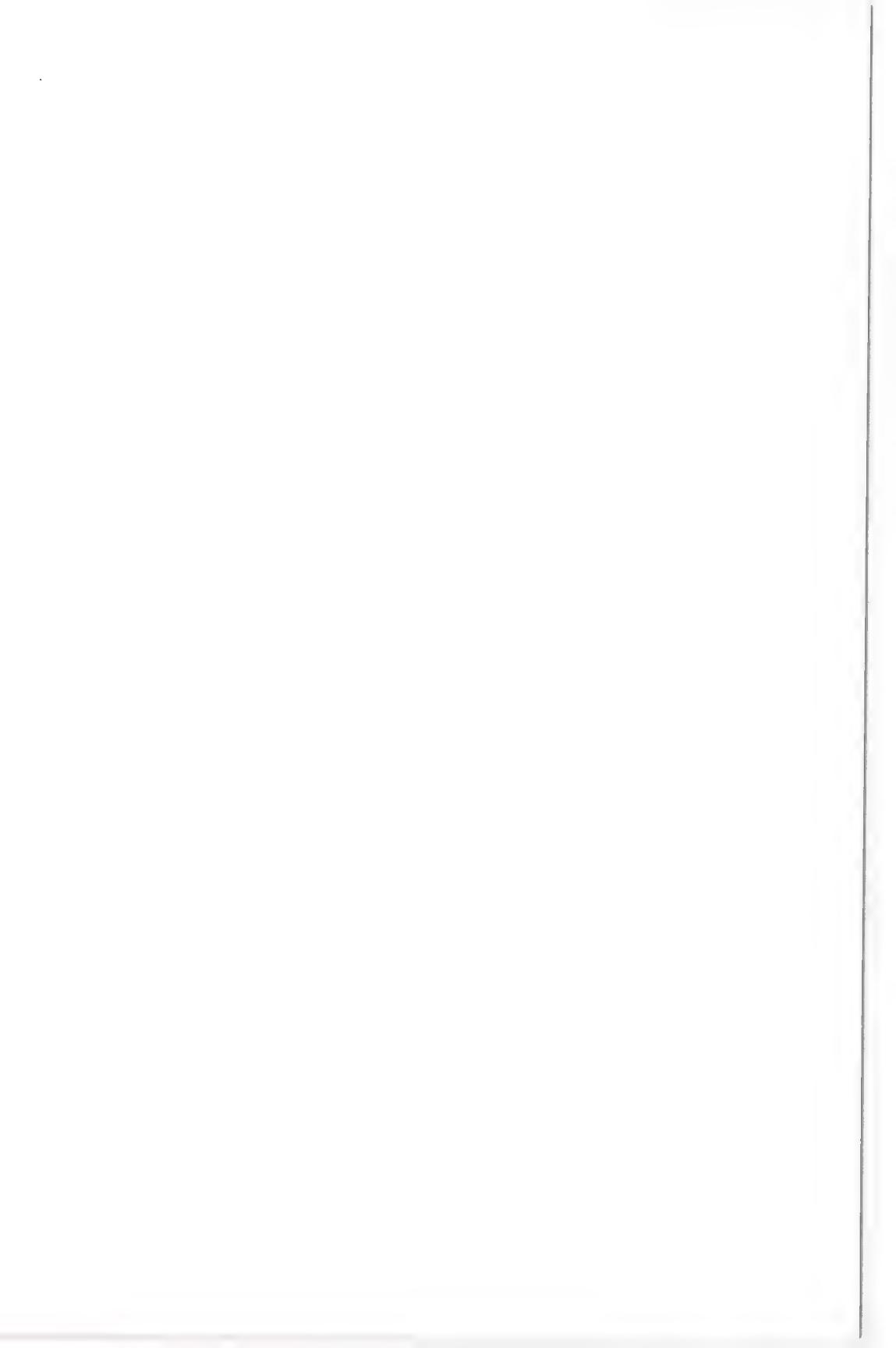
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# Defining Quality Customer Service Competencies at University of Wisconsin-Stout's Memorial Student Center

**Sarah L. Crawford**

Applied Psychology, M.S.

**Advised by Dr. Lou Milanesi**

## Introduction

The purpose of this project was to assist the University of Wisconsin-Stout's Memorial Student Center (MSC) toward improving and maintaining their quality of customer service. This was the first of a two-phase research effort designed to provide the information required by the MSC to accomplish these goals. This stage of the research protocol included an extensive review of the literature related to customer service, organized and extracted critical themes from this literature, examined existing measurement scales, and designed a comprehensive measure of customer service goals and processes. Accordingly, this primary stage was organized around the following objectives:

- 1) From the literature, compile a comprehensive list of all dimensions of customer service cited as contributing to quality.
- 2) Using the broad content defined above, build the research instrument used in both phases of the investigation.
- 3) Through data collected from MSC employees, construct the profile of optimal customer service as envisioned within the organization.
- 4) Report the data from the employee survey to guide improvements in existing service training modules and develop new ones.

The second stage of the overall plan used a survey instrument designed for this study in an effort to profile the dimensions of optimal service as reported by MSC customers. The new customer-defined profile was then contrasted with the provider-defined profile from this study. This allowed MSC staff to map those aspects of service important to an optimal working environment within the MSC (provider-defined profile), isolate those dimensions of service central to interactions with clients (customer-defined profile) and discover any gaps in meeting customer expectations (customer-defined expectations not included in the provider-defined profile).

## The Importance of Customer Service

Understanding customer service is one of the utmost priorities for many companies. Service is a valuable resource and, if customers do not receive the

service they expect, they will go elsewhere (Graham, 1994). Horovitz (1990) defined service as being "measured in terms of freedom from inconvenience and added value of products, that is, in terms of basic service features and the customer's experience with the service" (p. 13).

Zemke and Woods (1998) explained that it is vital to be concerned with customer service employees because they have the ability to retain the customer base. It was also noted that some managers view customer service as separate from their department. These managers believe that customer service is supposed to take care of customer complaints, problems and questions, and they often overlook customer service being the responsibility of the whole organization, each department contributing in its own way. In addition, Greenberg (1996) mentioned that customer service representatives have the potential to clear up situations and deal with them on their own without having to call on managers or supervisors. Such efficiency greatly facilitates the process, leading to satisfied and loyal customers.

Loyal customers are important and essential to business. Research has shown that 65% of a typical company's business comes from current loyal customers (Tschohl, 1998). Perlik (1999) stated that customer loyalty increases when a complaint is handled effectively and also includes guidelines to address customer concerns. Employees should apologize sincerely, involve the customer in the resolution, fix problems quickly, do extra for the customer, follow up with the customer and confirm repeat business. Businesses that concentrate on finding and keeping good customers, productive employees, and supportive investors continue to generate greater results. Loyalty is one of the great producers of business success (Reichheld, 1996).

While many organizations realize that it is important to understand customers' needs, many find that it is not easy to determine the importance of particular consumer demands or implement a plan to satisfy them. Meister, Chambers and Shehab (2000) stated that 92% of the executives from a Forrester Research survey believed that a common view of the customer is important or needed, but only 38% believed that they would reach that goal in one year. Failure to provide the desired level of service to the customer often results from the organization's failure to realize the complexity of the service process. As the following review describes, service hinges on a variety of factors that occur during exchanges with the client, but it also is determined by numerous exchanges that occur between company employees before and during the contact with the consumer.

### Characteristics of Service-related Interactions with Customers

The employee/service provider and customer often interact and communicate, which is also a large aspect of customer service. Employees have the ability to make the customers' experience positive or negative based on this interaction. Harris (2000) asserts, "Customer service is anything we do for the

customer that enhances the customer experience". An analogous perspective comes from Zemke & Woods (1998) which states, "customer service is a relationship with people who are essential to everything you do; meeting the needs and expectations of the customer as defined by the customer; used to create a mutually beneficial relationship between itself and those it serves; and a proactive attitude that can be summed up as: I care and I can do." Similarly, Evenson (1999) explained that people skills are at the root of good customer service. People skills include interpersonal relations, problem solving, teamwork and leadership. These skills also foster a positive attitude, effective communication, courteous and respectful interaction and the ability to remain calm and in control in difficult situations.

Many departments in various organizations may have slightly different service dimensions. However, certain dimensions which may/may not have been developed with the consideration of customers' expectations and perceptions seem to relate to almost every service business.

Tangibles include the physical goods and facilities, equipment, and appearance of personnel (Booth, 1999; Dube, Renaghen, and Miller, 1994). Reliability includes the employee having the ability to perform the promised service dependably and accurately. It also involves understanding the needs and perspectives of others and being conscientious, (e.g. hard-working, well-organized and reliable) (Cagle, 1998; Dube, Renaghen, & Miller, 1994; Greenberg and Sidler, 1998). Responsiveness involves aggressiveness and willingness of employees to help customers and provide prompt service (Dube, Renaghen, & Miller, 1994; Greenberg & Sidler, 1998). Assurance includes the knowledge and courtesy of employees and their ability to inspire trust and confidence (Cagle, 1998; Dube, Renaghen, & Miller, 1994). Empathy involves caring and the individualized attention the organization provides to its customers. Empathy also involves being able to identify emotionally with employers and customers (Dube, Renaghen, & Miller, 1994; Goodman, 2000; Greenberg & Sidler, 1998). These dimensions should be seen in service businesses for customers to get the most out of their experience.

Booth (1999) noted that customers want attitude, knowledge, standards and initiative when receiving customer service. Booth (1999), Cagle (1998) and Evenson (1999) stated that communication skills are also critical in delivering customer service. Hyland (2000) suggested doing what the MSC is in the process of: list the most important customer service elements, and circulate questionnaires to customer service representatives and customers asking them what they think is important.

Zemke and Woods (1998) also mentioned ten common mistakes employees make with their customers. First, employees take the customer for granted. Second, employees use jargon, expecting the customer to understand their lingo. The customer may perceive this behavior as being rude and be unwilling to help. Third, employees speak so fast that the customer has to ask him/her to

repeat what was said. Fourth, employees give short, abrupt answers to the customer's questions. Fifth, employees do not appear like they care about the customer's complaint. Sixth, employees are not proactive when a problem arises. Seventh, employees are preoccupied with other tasks. Eighth, employees interrupt the customer or no longer listen believing they know what the customer is asking or saying. Ninth, employees make judgments about the buying power of a customer based upon his/her appearance, language, skills, or company's reputation. Tenth, employees argue with the customer. With any of these traits or behaviors listed above, it will be more difficult for employees to deliver quality customer service.

### Characteristics of Service-related Interactions among Employees

It is important to focus on the employees who deliver customer service because service begins on the inside of the organization. It begins with how individuals speak to each other and deal with each other (Martinez, 1997). This is important because the nature and tone of customer service interactions with clients is greatly influenced by the nature and tone of interactions between employees. Various factors contribute to the culture of service expressed by an organization including hiring practices, training, service policy and employee compensation.

Hiring practices. Poor service attitudes, beliefs and habits can be introduced into an organization through indiscriminant hiring practices. The way to identify and hire the best candidate for any job is to ask the people who know and understand the job best, who know the clients best, and who know the work group best. It takes more time than other hiring processes, but it is better to spend time up front and hire the best person for the job rather than to spend time trying to correct problems later. For example, Sunoo (2001) reports a study by Reid Systems in Chicago revealed some problematic responses to the pre-employment assessment questions they used to gather data on pre-existing customer service attitudes and preferences among potential employees. The results showed that:

- 46% said customers have to follow the rules if they are going to help them.
- 45% said they believe that customers should be told when they are wrong.
- 34% said they would prefer to work behind the scenes, rather than with the customers.
- 13% said they believe that if customers don't ask for help, they don't need it.
- 10% said they do not feel it is necessary to help a customer if the request falls outside their area of responsibility.
- 6% said they have repeatedly argued with customers and coworkers in recent jobs.

To avoid poor hiring choices, Ludwick (1995) suggested sitting down with the work group before the recruitment process begins and identifying the knowledge, skills, abilities, and characteristics that the team members feel are

important or critical to continuing the work of the team successfully.

The interview itself is important to accomplish four things. First, it is a way to validate what the applicants' resume says. Second, the interview is a way to gain insight into the applicants' work ethic. Third, it is a way to gain a sense of how the applicant would fit into the organization. Fourth, the interview is a way to gain a feeling that the applicant likes the organization and whether they can be trusted (Vessenes, 2001).

Training. "Training is at the forefront of organizational priorities, and innovation in training is one of the most crucial aspects of the quality improvement process" (Hiam, 1992). Training has started to focus on aspects other than developing skills and discipline on-the-job and has moved to process improvement. Ernst & Young and the American Quality Foundation found that only 20% of United States businesses focus on process improvement whereas Japanese firms focus on process improvement 50% of the time. Process improvement involves continuously reviewing, analyzing, incorporating, changing consumer expectations, and refining the process so that products and services continuously improve (Lin and Darling, 1997).

According to Lin & Darling (1997), there are two consequences to be expected from customer service training: greater focus on job performance and personal enrichment. The first benefit is the improvement of necessary skills for the employee to do his/her job successfully. The second benefit of customer service training is the increase in self-efficacy of the employee (Lin & Darling, 1997). Self-efficacy is a person's expectation that he/she can successfully execute the behaviors required to produce a desired outcome (Bandura, 1977).

Booth (1999) suggested that training should be used in many areas. Training can help employees develop a positive attitude about themselves and seek opportunities to serve customers. Training has the potential to teach employees how to communicate effectively with customers, to become more positive and powerful representations of their business, to listen more attentively to customer needs, to develop a professional service manner, and to maintain a neat, professional appearance.

Training should not only lead to skill improvement, but should also change the way employees think and view their jobs (Lin & Darling, 1997). Training must tell employees why it benefits them to have good customer service and what they are trying to accomplish as a team instead of what not to do on the job (Hartill, 2000).

Service policies. Guidelines to take customer service to a new level come from Booth (1999). Employees should learn to think from a customers' point of view and let customers know what to expect and when. Employees should be able to plan for contingencies, listen and ask new customers how they heard about the organization. They should also be able to bring customer service to the management table for input on product development and marketing activi-

ties and put the customer at the top of the pyramid and be a winner – it's expensive and impractical to argue with customers.

Gerson (1998) believes his customer service plan has the ability to enhance customer service as well. First, he noted that performance standards should be established for customer service. Next, the commitment to service must begin at the top of the organization. While customer service has to start and be driven by top management it should also be visible to customers. Finally, it is important to train employees in service quality. Measuring the level of service is also important for improving customer service. The level of service was measured in the present study by what employees believe is important and will also be done with customer surveys. Gerson (1998) suggested letting the customers define what "service" is, set service standards, and abide by them.

### Using Research to Shape Service Delivery

Morris (1996) stated that employee surveys are a way to listen to what is going on inside the company and the voice of the internal customer. Employees are both customers and suppliers. They are customers because they receive products from other departments and they are suppliers as they help assist other departments with their inquiries. It is important to get both the internal customer's point of view as well as the external customer's point of view.

According to Berry (1995), researching employees is critical in service improvement. Many companies do little or no employee research when attempting to improve their service, but will spend a lot of time and money researching only the customers' perspectives. Employee research may help reveal the causes of poor service because they experience the service delivery system every day and they see it from a different vantage point than do customers.

In a study of an industrial services company, Berry (1995) found, after asking both customers and employees to evaluate the company's service quality, that employees' ratings were significantly less favorable than the customers. This may be because the employees knew more about the company's weaknesses. Customer and employee research play complementary roles; one is not a substitute for the other (Berry, 1995).

If input is not gathered from employees, organizations run the risk of making the same errors they always have and also they may not develop as teams (DeVoe, 1999). Getting feedback from employees is just as important as getting feedback from customers. Employees also need to feel that their suggestions/opinions will not be criticized. DeVoe (1999) also stated that it is important to show staff members what was done with the surveys they completed.

Not only is employee feedback important, but research also shows that it is not pay, benefits, or dissatisfaction with the job that provokes employees leaving. Lilienthal (2000) found that 67% of employees who leave their jobs are satisfied with their jobs, but they do not feel listened to or valued. Surveys of

employees can also give management an important idea of the organization's main issues and the results have the potential to set the framework for ongoing feedback to be gathered (Lilienthal, 2000).

Studies, by Gerson (1998) and Naumann and Giel (1995), demonstrated that customer satisfaction is irrevocably linked to meeting or exceeding customers' expectations. Thus the service provider must understand what specific customer needs exist through research.

## **Summary of the Literature Review**

The literature clearly documents what most people believe to be obvious; namely, that customer service is an important, if not the most important aspect of doing business. However, these studies as a whole also describe an important paradox. While service is highly valued by both the consumer and provider, the service efforts of many organizations who want to deliver quality services fall far short of customer expectations. Several factors are suggested as being crucial to the success or failure of service efforts.

Providing service is a complex interaction between factors directly related to exchanges with the customer and the internal organizational processes that shape a culture of service. This dimension of organizational culture creates the social and functional context within which service takes place. It molds the beliefs, attitudes, and behavior habits of service providers. Additionally, it creates a functional model of service that either facilitates or restricts the effective and efficient responses of service staff. Too frequently, this culture of service evolves more through corporate inattention versus deliberate, orchestrated and organization-wide planning and design.

Service is too frequently based upon assumptions versus verified information. Such assumptions about service usually create limitations in customers' ability to obtain quality service, or alternatively, clients can face a series of complex service options that fail to address their specific needs. Existing models of customer service vary considerably adding to confusion among service managers. Service models range from holistic approaches that encompass many factors to highly specific designs that concentrate attention on a few central areas of service management. Therefore, organizations must collect timely information regarding both internal functions and customer interfaces to effectively provide service using a customized model. As stated above, this study designs and initiates such a process for the UW-Stout MSC.

## **Methods**

### **Participants**

A full census of Memorial Student Center (MSC) staff was conducted to best profile customer service attitudes and beliefs among the current employees. Surveys were administered to all (398) employees of the MSC, including permanent staff and student staff. Of this total, there were 27 (6.8%) perma-

nent staff and 371 (93.2%) student workers.

### Instrumentation

A survey containing 39 items rated on a 7-point Likert-type scale was developed for use in the study. The questions were drawn from the themes extracted from the review of the literature, and addressed general areas such as problem solving, attitude, work qualities, teamwork, interpersonal skills, critical thinking skills, and personal development. All questions were rated on a scale ranging from "1" strongly disagree to "7" strongly agree. Five open-ended ("other") responses were included to give employees the opportunity to provide additional ratings of areas they felt the survey omitted. Demographic questions were also included which asked the employees if they were part of the student staff or permanent staff and in which department they worked. The researcher, the Assistant Director and the Research Advisor contributed to the construction of the questionnaire.

### Procedure

The questionnaire was reviewed and approved by the Assistant Director of the MSC, the Research Advisor, and the Institutional Review Board (IRB) at UW-Stout. All supervisors were given a large envelope for staff to place their surveys, which were then returned to the primary researcher. Thus, an attempt was made to administer the survey to all permanent staff, managers, and employees of the Memorial Student Center (MSC). The total number of surveys administered was 398. A total of 189 surveys were returned for an overall response rate of 47.5%. Twenty-three (5.8%) participants reported themselves as full-time staff, 162 (40.7%) reported being part of the student staff and four (1%) participants did not report whether they were full-time or student staff. The remaining 209 (52.5%) did not return the survey.

### Data Analysis

All quantitative data was entered in SPSS and analyzed using descriptive statistics, correlations, t-tests, and factor analysis. Qualitative data was analyzed by first, identifying open-ended responses that could be seen as replicating existing Likert scale items and, second, to identify and organize qualitative responses that introduced unique concepts.

### Results

Mean, standard deviation, and median values were calculated for the individual items across the entire sample. MSC employees did not make meaningful distinctions between the items and rated each at the top of the 7-point rating scale. Interestingly, a 7-point scale was selected trying to avoid ceiling effects that occurred anyway.

A series of independent sample t-tests were used to examine rating differences between permanent employees and student employees. The means of only

two items were significantly different across groups. First, "show confidence in other team members" (Student Staff Mean = 6.3, Permanent Staff Mean = 5.7,  $t = 2.2$ ,  $df = 183$ ,  $p = .027$ ). Second, "show trust in other team members" (Student Staff Mean = 6.4, Permanent Staff Mean = 5.8,  $t = 2.3$ ,  $df = 182$ ,  $p = .021$ ). Students rated showing confidence and trust as more important than the permanent staff. This may result from their position in the organization. Students are likely the least experienced and have the least job security. Based on the lack of experience, they may not be given confidence or trust of employers. The reader is cautioned regarding over-interpreting these differences in that significance at the .05 level suggests that two differences would be observed (out of 39 analyses) simply by chance.

Factor analysis was employed to identify and map component factors within the items. A single monolithic factor emerged when Principal Component (PC) extraction was applied without rotating the matrix. An identical singular factor resulted when Varimax rotation of the matrix was attempted after PC extraction because the matrix could not be rotated after the massive factor emerged. The single factor had an Eigenvalue of 31.17 and explained 79.9% of the total variance across the 39 items.

Ideally, separate factor analysis would test for potentially different factor structures across the two worker groups. However, subdividing the sample created group sizes that would not be sufficient for such procedures. Instead, individual Pearson correlation matrices were used as a simple check for differential patterns. Similar to the above findings in the factor analysis, all items were significantly intercorrelated within both groups. All items were significantly correlated with all other items at the .05 level, with correlation coefficients ranging from .56 to .91 in the student staff group and from .71 to .98 in the permanent staff group.

Qualitative analysis revealed that 23 participants (12.2%) offered open-ended responses. Three (13.0%) responses came from permanent staff and 20 (87%) responses came from student staff. These items were subjected to qualitative content analysis. It was determined that 48.9% of the responses could in fact be linked to existing scale items, whereas 51.1% of the responses were determined to be unique. Student staff's responses seemed to fall into more of a job performance category than did permanent staff's responses. Three of the four responses from permanent staff seemed to relate to job dissatisfaction.

## Discussion

As described above, the customer service literature appears to fall evenly between two fundamental models of service. Several studies describe highly specific approaches to service (Evenson, 1999; Dube, Renaghen & Miller, 1994; Booth, 1999; Cagle, 1998; Greenberg & Sidler, 1998; Goodman, 2000) as opposed to others who favored more global, inclusive definitions (Horovitz, 1990; Harris, 2000; Martinez, 1997; Zemke & Woods, 1998,

Gates, 1998). The results from this study unambiguously indicate that those MSC staff that provided data hold a global view of providing service.

The top ten statements from the factor analysis were: Interact in a friendly courteous manner, be willing to collaborate, listen effectively, follow through with commitments, be willing to compromise, show concern for the needs of others, stay focused on tasks, give continuous attention to customer satisfaction, readily accept feedback on performance, and display positive self-image (one's conception of oneself or of one's role).

The unique qualitative comments have a few similarities within their work groups. For example, student staff participants showed that being on time (4 responses), presentation of self (3 responses), smiling (3 responses), and enjoying the job and having fun at work (3 responses) were all important areas of delivering customer service. Permanent staff did not feel the same main traits were important. Instead, they mentioned 4 unrelated traits of delivering quality customer service. First, be treated fairly by management. Second, be paid a living wage. Third, maintain a healthy lifestyle. Fourth, student employees are not treated differently than LTE's. Student staff responses seem to fall into traits they believe are important to their superiors, whereas the permanent staff responses seem to relate to traits important to them at the present time and not what they should think. As mentioned above, three of the four permanent staff responses seem to indicate some degree of job dissatisfaction. Of the total number of permanent staff surveyed (27), 11.1% of the permanent staff are indicating some degree of dissatisfaction. Of the permanent staff that returned surveys (23), 13% of them are dissatisfied with their job in some way. It is important to point out that these permanent staff members and other employees, while they may not be completely happy, it may be transmitted down to employees. As mentioned in the literature review, upper management may be a reason for poor service if he/she sets a poor example (Citomer, 1999; Harris, 2000). Job performance may be important to the student staff because they do not know what is completely expected of them.

Reasons for representation of permanent staff responses versus student staff responses may be a factor in missing data (52.5% of administered surveys). Permanent staff accounted for 23 (85.2%) returned surveys of 27 administered to their group, whereas the student staff accounted for 162 (43.7%) returned surveys of 371 administered to their group.

The request for conducting this assessment of defining quality customer service for the MSC was given by the Associate Director of the MSC in order to evaluate the necessary ingredients of quality customer service. This phase included the staff of the MSC in order to determine the internal culture of service expressed by the MSC. The second survey will be helpful in defining quality customer service traits important in delivering quality service. By comparing results of the employee survey and customer survey, training sessions will be developed and hiring concentrations will be defined.

\* As reported above, this study appears to indicate staff favoring the global all-inclusive model of customer service providers. Staff members are unlikely to discriminate between factors described in the models when hiring. More information is needed to define what is needed to serve clients.

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# A Family Impact Analysis of The Leave No Child Behind Act: How This Act Will Impact Children and Their Families

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## Introduction

Increasingly, policymakers and their staff at all levels of government ask, "What effect does (or will) this policy or program have on families? Will it help or hurt, strengthen or weaken family life?" These questions, while sounding disarmingly simple, are, in fact, very complex. A policy may have different effects on different types of families and varying dimensions of family life. Family policy research may determine whether the intended goal of a policy is being met (Bogenschneider, 1993).

Family impact analysis is a family policy research method that assesses both the intended and unintended consequences of public policy and resultant social programs for children and families. The task of family impact analysis involves a systematic, structured method of identifying, describing and assessing the impact of a given policy on families (Bogenschneider, 1993).

This study utilizes family impact analysis criteria in the analysis of the Leave No Child Behind Act. On May 23, 2001, Senator Christopher Dodd of Connecticut and Representative George Miller of California introduced the Leave No Child Behind Act(S. 940/H.R. 1990). As of July 1, 2001, there were 67 cosponsors in the House of Representatives and seven cosponsors in the Senate. Two hundred organizations have supported this bill (Summary, 2001).

Marian Wright Edelman, the founder and president of the Children's Defense Fund, is working with legislators to help push this bill through Congress. It is the hope of Edelman and of many other child and family advocates that this bill will be the first federal child and family policy (Editorial: Left Behind, 2001).

This bill has many goals for children and their families. It will accomplish these goals by giving each child a healthy start, a head start, a fair start, and a safe start. This bill gives children a healthy start by ensuring health insurance for all children. In order to give all children a head start, this act will fully fund daycare, preschools, and other early childhood education opportunities for young children. The goal in giving all children a fair start is to take every child out of poverty. Finally, when each child is given a safe start, they will feel safe in their homes, in their communities, and after school (Summary, 2001).

Even though the Leave No Child Behind Act is centered on children, this bill is aimed at the child's families as well as the children themselves. The Children's Defense Fund and the sponsors of this bill recognize the fact that in order to help children they have to help out their families as well.

### A Healthy Start

Many uninsured children don't receive the routine and preventive check-ups that children with insurance receive. These check-ups are very important while children are growing. Not only do they save money in the long-run but they can prevent treatable infections from becoming life threatening. For example, if a child has an ear infection and her parents can't afford to take her to the hospital and they don't have health insurance, this treatable infection can develop into hearing loss for the child. In addition, many children without insurance end up in the emergency room, which is the most expensive type of treatment. Routine check-ups can prevent these situations from happening (Uninsured, 1999).

Yet even though it is so important to get children to the doctor throughout the year, many parents can't afford it and they don't have health insurance to cover the costs. Nine million children under 19 years old are without health insurance. Of these 9 million children, 90% are in working families (Edelman, 2001). In 2000, 11.6% of children were without insurance, which has actually decreased from 12.6% in 1999. This decrease in children without insurance is due to more employment-based health insurance, not government-based health insurance (Health Insurance Coverage, 2000).

As mentioned previously, the major goal of giving every child a healthy start is to ensure all have children health insurance. The Leave No Child Behind Act will accomplish this goal by implementing a new children's health insurance program that will be similar to Medicare for the elderly. Thus, with the combination of Medicaid, Children's Health Insurance Program (CHIP), and employment-based insurance, almost every child will be covered under health insurance (Summary, 2001).

### A Head Start

Research has proven that educational early childhood programs do help children do better in school. The areas that they especially excel in are math and language; they have fewer behavioral problems and can pay attention better in school. These children are also less likely to be held back a grade and/or be placed in special education programs (Quality Child Care).

Many low-income families can't afford or find these beneficial programs for their children. Forty-five percent of low income children ages three to five did get the chance to attend preschool; yet 75% of children of the same age in higher income families were also enrolled in preschool (Quality Child Care).

Currently the federal government does have programs to help parents get their children pre-kindergarten education or even daycare services such as Head Start and the Child Care and Development Block Grant. However, Head Start only reaches three out of five eligible children and only 12% of children who are eligible for the Child Care and Development Block Grant receive those services (New Investments).

The Leave No Child Behind Act will make sure every child will get a head start by fully funding Head Start for three and four year olds, and child care. Not only will this bill fund childcare for parents but it will also give parents a choice of childcare programs. This bill will also help states and their communities better train child care providers, make it easier for children to enroll in child care programs, and improve the quality of these programs (Summary, 2001).

### A Fair Start

The census bureau defines poor as; if a family's annual cash income is below \$13,290 for a family of three and \$16,400 for a family of four (New Data). One in six children live in poverty or 16.2% of all children. In every state, children were more likely to be poor than adults, with the youngest children being the most poor (New Data). The good news is that poverty rates for children have fallen over the last couple of years. The bad news is that children in working families who are below the poverty line have reached its highest level in 26 years. Over three out of four (77%) poor children have a parent who works sometime out of the year. One out of three poor children have a parent who works full time all year round (Overall Child Poverty).

As mentioned previously, one of the goals of the Leave No Child Behind Act is to lift each child out of poverty. Since so many poor children live in working families, this bill addresses the needs of these families. This bill will require family caseworkers to be knowledgeable of all the available resources for families in the area. This way a family will know which programs they are eligible for and will have the option of participating in these programs (Summary, 2001).

This bill will also allow education, along with work hours, to count for federal participation requirements. The education will help parents find better paying jobs. Another way that this bill will help working parents is by letting them keep partial cash assistance for a longer time after they start making money on their own. This will make sure parents are completely back on their feet before they are taken off welfare.

### A Safe Start

This bill also wants to guarantee children the right to be safe at all times. In 1998, 903,000 children were victims of child abuse and neglect. Seventy-five percent of the perpetrators of these children were parents and another 10%

were other relatives of the child. Also, in 1998, more children died from guns than pneumonia, cancer, influenza, asthma, and HIV/AIDS put together.

After school is the most dangerous time for children. A child's chance at becoming a victim triples during the hours of 3:00 pm and 6:00 pm. Children can also put themselves into dangerous and illegal situations such as using drugs, smoking, drinking alcohol, or becoming sexually active. It has been proven that youth are less likely to do these things if they are involved in after school activities (In America).

The Leave No Child Behind Act aims at protecting children from child abuse, gun violence, and making sure they are safe after school. This bill will make sure that at-risk children and their families will receive support from extended services of the child welfare system. The goal is to prevent problems from reoccurring and to reunite children safely with their families (Summary, 2001).

To protect children from gun violence, this bill will make sure that only law-abiding citizens can own guns. Only people who are 21 and older can own a handgun, and it will ban juveniles from possessing assault weapons (Summary, 2001).

Since it has been proven that children are safer when they participate in after school programs, this bill will fully fund these kinds of programs. This will make sure all kids have the choice to participate in healthy extracurricular activities (Summary, 2001).

## **Family Impact Analysis**

Using the Family Impact Analysis criteria developed by the Coalition of Family Organization (Ooms & Preister, 1988) the application of six guiding principles that serve as criteria are presented. The Act To Leave No Child Behind has been introduced in the United States Congress and, if passed, will target the needs of low-income children and their families.

### **Principle #1 — Family Stability**

When children are present in the family, it is very important that policies and programs stabilize families through promoting family, parental, and marriage commitments. The Act to Leave No Child Behind encourages parental competence. Part of being a good parent is having the capability to support your family. This bill will help parents take care of their families by giving them economic assistance, offering parent education classes, and making it possible for them to find and keep a job on their own.

This bill offers economic support through tax cuts, extended food stamps, and by allowing parents to receive partial assistance from the government while they begin their jobs. Part of the provisions of this bill are to make sure parents have the availability of parent education programs. These programs will teach them ways of appropriately addressing the needs of their children and in

doing so prevent problems from arising in families. This bill will also make it easier for parents to get out and find a job. Since this bill will provide funds for childcare, parents won't have to worry about their paychecks going right to day care costs. Since this bill would allow education to meet federal participation requirements, parents will also be able to get higher paying jobs, which they would not have been able to previously get because of their lack of education. By enhancing parental competence, this bill will make sure that children are taken care of properly.

### **Principle #2 — Family Support and Responsibilities**

Family policies are the most beneficial when they support family functioning rather than substitute or take over family functions. Part of providing support for families is to encourage parental responsibility. This act helps families perform their responsibilities through economic support, parent education, and help to working parents. The reason why this act doesn't inappropriately substitute families' responsibility but instead strengthens families' ability to support themselves is by supporting measures that will help families in the long run. For instance, by allowing for education to count for federal participation requirements, parents will be able to get higher paying jobs that require a certain education level. Higher paying jobs and the education that preceded the job, will definitely benefit parents and their families in the long run. The higher paying jobs will probably offer more benefits such as health care insurance and retirement plans. The education that the parents receive will open up more options for finding more lucrative jobs in the future. It is important that policies that help families have an end goal that will strengthen the families' abilities to make it on their own. Edelman and other supporters of this bill would say that the bill has succeeded when the families targeted by the bill would be able to be self-sufficient due to the bill's assistance.

### **Principle #3 — Family Involvement and Interdependence**

A necessary criterion of family policies is to make sure the policy or program involves all family members. The policy needs to recognize the importance of family ties and interdependence. Only by recognizing this fact will the policy be the most effective. The Leave No Child Behind Act recognizes that in order to target needy children, the policy has to target their families as well. This Act balances the needs of children and the needs of their parents appropriately.

One example of this is children need childcare and preschool in order to be prepared for school. Well, this bill will make sure children have access to childcare and preschool. Not only will the child care and preschool be fully funded but this bill will give parents a choice between places they want to send their children. This way, they can choose the day care or preschool that best applies to the needs of the family.

Since this bill caters to both children and their parents, there aren't many competing needs within the family, although there may be some competing needs between families. For instance, one might ask, "What are the qualifications for receiving assistance from this bill and how will this bill decide who will get what?" This bill will look at the children and then decide what kind of assistance they need. If a child doesn't have health care insurance, this bill will provide that for them. If a child is living in poverty, this bill will help the child's parents become more marketable with education, which will help the parent find higher paying jobs. These are just a couple of examples of how this bill will look at the children, determine if they qualify for assistance, and then help the whole family.

#### **Principle #4 — Family Partnership and Empowerment**

An effective way to empower a family is to treat all family members with trust and respect, whether it is the children or the parents. Another successful way of empowering families is by giving them information and choices. Throughout all of the written materials that were researched, it was explicitly implied that families are part of the implications of the Leave No Child Behind Act. In the summary of the Leave No Child Behind Act, it was obvious that families were just as important as the children. In fact, half of the measures in the bill directly affect parents so they can in turn help out their children.

This bill allows families to have both autonomy and choices. The family will have the freedom to decide to participate in any of the programs that this bill will make available to them. If a family, for some reason, does not want their children to go to preschool, this bill will not force them. The purpose of this bill is to empower families by giving them choices, not forcing them to do something against their wishes. Furthermore, not only will this bill fund these programs but this bill will also give them a choice of which one they want to utilize. This way they can choose which place would better suit their families.

#### **Principle #5 — Family Diversity**

A more inclusive way to define "family" is using a functional definition rather than a structural definition. In other words, defining what a family does rather than what it looks like. A functional definition of family recognizes the reality of diverse family forms and supports them as they perform family functions.

This bill is intended to help all families with children under the age of 18. In order to make sure all children are taken care of, this bill targets low-income children and their families. It will ensure that all children will have the same opportunities, including, but not limited to, day care, preschool, and health care.

This act does not penalize any family structure, as long as they have children under 18. This bill does not discriminate against single parents, gay or

lesbian parents, blended families, married couples, divorced couples or any other family structure that might go against status quo. This bill strives to help children and it doesn't matter how their families are structured.

Along with this bill being open to all different types of family structures, it is also open to different cultures, different communities (rural, urban, or suburban), and any other factor that might make one family different than another.

Throughout this bill there are rewards for working parents. The bill makes it easier for parents to go out and get jobs. It offers parents free childcare, health care coverage, and transportation assistance. The goal of these programs is to give parents incentives to find and keep a job to keep their families above the poverty line.

Even though the bill targets low income children, there are programs that will benefit all children no matter what their income level. Most of these programs are under the Safe Start section of the bill. Children in middle and high incomes also have the right to feel safe at all times. Crime doesn't isolate itself among low-income children. Measures like gun safety laws, preventing child abuse and neglect, and giving children a place to hang out after school will benefit all children across the income brackets.

### **Principle #6 —Targeting Vulnerable Families**

Policies should show priority to those children and families who are in the most need. Prevention should also be a priority in policies. As previously mentioned, even though the bill is for all children, it targets low-income families. This policy fills in the cracks for the services that parents can't provide or the government currently isn't providing.

One of the major priorities within this bill is health care coverage for all children. The children who aren't covered under health insurance are considered part of vulnerable families because they won't receive routine and preventive health check ups. Since they don't receive these services they are more prone to health problems, which will financially strain the family and negatively affect the child in all aspects of their life.

A major theme throughout this bill is prevention. A number of programs within the bill are preventive measures. The two main preventive programs are parent education and health care insurance for children. If a parent participates in parent education programs, they will learn how to appropriately tend to their child's needs. For example, the parents will learn ways of developmentally appropriate child guidance that will create new discipline options for the parent. This education will enable parents to use healthy guidance measures with their children and prevent them from using harsh or corporal punishment.

As discussed under a Healthy Start, health insurance is a big preventive measure for children. Health insurance will make routine and preventive check-ups affordable for parents. Parents won't have to jeopardize their children's health because they have to use their paycheck to pay rent, clothes, and

other necessities. The Children's Defense Fund and the sponsors of this bill know that proactive measures make much more sense than reactive measures. Proactive programs will save money and it will greatly benefit the child and her family.

## **Conclusion**

Since children can't vote, their small voices often go unheard. Thankfully, there are people who care about our nation's children. Marian Wright Edelman and the Children's Defense Fund make up a large part of these concerned people that are doing something about it. They believe that every child deserves a healthy start, a head start, a fair start, and a safe start. If the Leave No Child Behind Act is passed by Congress, these goals for children will be accomplished.

Since children aren't isolated from their families or communities, this act will support the families and communities so they can do their part in helping the children. The bill will make it easier for parents to find and keep higher paying jobs.

The Leave No Child Behind Act will accomplish many other goals for children and their families. The bill will make sure all children will have the opportunity to go to the doctor when they are sick, to go to preschool to learn, and to have food on the table when they are hungry. Most importantly this bill will ensure no child will be left behind.

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# Invest in the Future with Five A Day

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## Abstract

The "5 A Day" program is the nation's largest public/private partnership and the only initiative promoting all produce. This program encourages people to eat 5-9 servings of fruits and vegetables every day for good health. There is a substantial need for U.S. children to attain healthy eating practices (such as increasing fruit and vegetable consumption) that will enable them to attain healthful weights and prevent long-term health problems, such as coronary heart disease, cancer, obesity, stroke and osteoporosis.

Members of Phi Upsilon Omicron researched the 5 A Day program and generated ideas for fun and effective classroom activities. From these ideas, four unique programs were developed. One, a play, sought to introduce 5 A Day to fourth grade students through song and dance. In another, second graders prepared and sampled healthy snacks made with celery and raisins. A third program, targeted at fourth graders, turned the school lunch menu into a game entitled "The Great Fruit and Vegetable Search." Finally, adolescents identified serving sizes and learned supermarket tips for selecting fruits and veggies. These programs reached students ranging from ages 8-17 in Wisconsin and Minnesota.

The benefits of the hard work and dedication that went into this project will not be seen immediately. It is anticipated that the information provided to the youths will be applied in their daily lives and passed down from generation to generation, leading to decreased incidence of chronic diseases.

## Literature Review

There is a substantial need for U.S. children to attain healthy eating practices (such as increasing fruit and vegetable consumption) that will enable them to attain healthful weights and prevent long-term health problems, such as coronary heart disease, cancer, obesity, stroke and osteoporosis (Skinner, Carruth, Houck, Bounds, Morris, Cox, Moran & Coletta, 1999). Many studies have shown that higher intakes of fruits and vegetables are associated with a lower risk of cancer at most sites and may reduce the risk of coronary heart disease. In fact, people who eat five or more servings of fruits and vegetables each

day have half the risk of developing cancer compared to those who only eat one or two servings a day. Additionally, several studies have found that poor nutrition has negative effects on growth, development, and cognitive abilities, which are major concerns for children. But children are not eating the recommended amounts of fruits and vegetables; children ages 2-18 have an average daily consumption of 2.6 servings of vegetables and 1.6 servings of fruits (U.S. Department of Agriculture, 2001). Fewer than 15 percent of elementary students eat the recommended five or more servings of fruits and vegetables every day. Poor nutrition affects kids' energy levels, ability to concentrate, and ability to learn, which can lead to increased illness and absenteeism (Dole, 2001).

Diets low in fruits and vegetables not only affect people physically, but also economically. Nearly 250 billion dollars are spent each year on health care costs due to diet related diseases from diets that are too high in fat and too low in fruits and vegetables (5 A Day, 2001).

The 5 A Day program is the nation's largest public/private partnership and the only initiative promoting all produce. Its mission is to increase consumption of fruits and vegetables to an average of five or more servings a day to improve the health of Americans through a partnership among the health community, government agencies, the fruit and vegetable industry, and other private sectors.

Dole Food Company is a founding member of the National 5 A Day for Better Health Program. As part of its commitment to children's nutrition and the National 5 A Day For Better Health Program, Dole's 5 A Day web site provides access to a number of educational resources designed to help increase awareness of 5 A Day.

As a result of the 5 A Day program, children and adults are learning about eating more fruits and vegetables. In fact, since the 5 A Day program began in 1991, consumer awareness of 5 A Day has increased from 8 percent to 39 percent at the same time as the average fruit and vegetable consumption increased half a serving from 3.9 servings a day to 4.4 servings (5 A Day, 2001).

Our chapter wanted to contribute to such a successful program. We thought a school setting would be appropriate since studies have shown that some of the most important factors in determining someone's fruit and vegetable intake are the number of servings they think they should have in a day and whether they have been in the habit of eating many fruits and vegetables since childhood (Krebs-Smith, Heimendinger, Patterson, Subar, Kessler, & Pivonka, 1995). In this setting, we could focus on these factors.

## Methods

Members were given the objectives, which are seen below, as well as an assessment to give to the students. This allowed members the ability to plan activities in a manner to teach the students and then effectively find out what they learned from the activity.

**Specific outcomes to be achieved**

- 1) Participants will have greater knowledge of the importance of eating 5-9 servings of fruits and vegetables every day

- 2) Participants will have greater knowledge of the Food Guide Pyramid (FGP)

**Parameters on the scope and content of the project**

- 1) Projects must be developed to inform students of the 5 A Day program

- 2) Members will conduct educational sessions and discuss the following:

- a. What is 5 A Day?
- b. What is the FGP?
- c. What are phytochemicals?
- d. What is the importance of physical activity?

**Measurable Objectives**

The students will be able to:

- a. Show awareness of the 5 A Day Program
- b. Match food items to appropriate food group
- c. Identify that phytochemicals give fruits and vegetables their bright colors
- d. Recognize that one should participate in at least 30 minutes of physical activity everyday

**Evaluation**

Project success was evaluated by employing a pre- and post-assessment. A sample questionnaire was provided and groups were allowed to modify them as they felt necessary. The pre- and post- assessments were the same. The questions that could be included (but not limited to) were as follows: 1) How many servings of fruits and vegetables should one eat in a day to stay healthy? (a response of 5 or greater was considered correct); 2) Matching foods to the proper food group; 3) Substances called phytochemicals (fight-o-chemicals) give fruits and vegetables their color and keep you healthy; 4) How many minutes should you be physically active a day (playing, running, sports)?; 5) How many times did you eat fruits and vegetables yesterday? and 6) What is your favorite fruit or vegetable?\*

To determine student awareness of the 5 A Day program, Question #1 asked "How many fruits and vegetables should you eat each day to keep you healthy?" For this objective to be successful, the students had to answer this question correctly.

To determine if students were able to name and match food items to their appropriate location in the Food Guide Pyramid, answers to Question #2 were reviewed.

To determine if students chose to increase their fruit and vegetable consumption by at least 2 servings, the number given in Question # 5 in the post questionnaire had to be at least 2 servings greater than their pre-assessment answer. (This answer was compared to baseline answer and if the answer was greater by 2 or more in the post-assessment compared to the pre-

assessment, it was assumed fruit and vegetable consumption increased by 2 servings per day.)

\* One session used this question

The following sections explain each of the individual educational sessions.

### **Gilman Elementary School (Gilman, WI)**

#### **Who?**

Fourth grade students attending Gilman Elementary School (27 students ages 9-10).

#### **What?**

The 5 A Day Live musical performance (obtained from the Dole 5 A Day website) was used as a component in this nutrition education program. Based on an evening news broadcast, 5 A Day Live got the students singing and dancing while delivering the 5 A Day message in an entertaining performance.

#### **When?**

December 4, 2001 at 8:30 a.m. and 1 p.m.

#### **Where?**

Gilman, WI

#### **Why?**

Due to the fact that children want learning to be fun and they learn best by active participation, the researchers were inspired to develop a play. To date, there are no studies on the effectiveness of a play as a nutrition intervention; but, school-based interventions have shown considerable promise in promoting healthful dietary behaviors among children, particularly interventions involving multiple components (Perry & Bishop, 1998). Many of these studies have tested the effectiveness of school-based interventions that use the Social Cognitive Theory as a tool to develop fruit and vegetable nutrition education programs.

Professionals have suggested that intervention programs should provide concrete messages (such as consume 5 or more servings a day), and we believed this play would provide this concrete message.

#### **How?**

Initial communication was made by contacting the principal of Gilman Elementary by phone and the two fourth grade teachers via e-mail. A copy of the play and a cast sheet were given to the teachers to select the cast members because they know the personalities and talents of the children. During the months of October and November 2001, we met with the class and teachers

every Tuesday morning to rehearse the play.

Prior to beginning production, we distributed a 5-item assessment among students. This was used to determine if students were aware of the 5 A Day Program and knowledgeable of the Food Guide Pyramid (FGP). We held up six food models individually and asked the students to place them in the proper location of the FGP. They then completed the remaining questions. After the assessments were collected, we discussed where each food item belonged in the FGP and how 5 A Day was derived from the FGP. We utilized a FGP poster during this discussion.

We, along with the teachers and students, contributed a lot of time and effort into the making of this play. The three of us made posters and supplied most of the props. We obtained a FGP poster from Gilman Head Start and food models from UW-Stout. The students made their own costumes during art class. The fourth grade teachers helped construct props and teach the play's songs.

Fourth grade students performed the play for elementary students, community members, and parents on December 4, 2001 at 8:30 a.m. and 1 p.m. in Mrs. Stendel's classroom at Gilman Elementary School.

A post-assessment was administered to the students after the 8:30 a.m. performance. The results were compared to the pre-assessment and were then used to evaluate the program's effectiveness.

### **Promotion Strategies**

Publicity was generated by informing a local television station, WEAU TV-13, and newspaper, The Star News, of the performance. Along with a description of the play, invitations were sent to parents/legal guardians.

### **Oaklawn Elementary School (Menomonie, WI)**

#### **Who?**

Second grade students attending Oaklawn Elementary (16 students ages 7-8).

#### **What?**

Discussion of the FGP and importance of having 5 A Day

#### **When?**

Friday, January 25, 2002

#### **Where?**

Menomonie, WI

#### **Why?**

Repetition is a great way for students to learn. As first graders, the students learned about the FGP. The discussion was a great form of review and emphasized the importance of the 5 A Day program.

**How?**

On Wednesday, January 23, 2002, the students were given a pre-assessment to evaluate their knowledge prior to the January 25th discussion. After reviewing the assessments, we knew what needed to be the focus of the conversation. Only three out of 16 knew how many fruits and vegetables they should eat a day and only five out of 16 students knew what phytochemicals were.

The students were given an opportunity to speak out in class about examples of each food group. They also talked about what they ate for lunch and which food group each item fell under. The word phytochemicals was then placed on the board and the class learned how to pronounce it. They also learned that phytochemicals were responsible for the bright colors in fruits and vegetables. Upon completion of discussion, the students were given a healthy snack named "Ants on a Log" (celery, raisin and peanut butter).

**United South Central Elementary School (Wells, MN)****Who?**

Fourth grade students attending United South Central Elementary School (64 students ages 9-10).

**What?**

Discussion and activity containing the 5 A Day program and related topics

**When?**

Friday, January 18, 2002

**Where?**

Wells, MN

**Why?**

The students were enrolled in a health class and were about to begin a month concentrating on physical fitness. This session was to give the students a jump start in health class and a great way to gear up for their physical fitness month.

**How?**

The session began by explaining what a pre-assessment is. The students were each instructed to complete the 5 A Day pre-assessment. After all students completed the assessment, they went over the answers and the students self corrected the assessments. Next they discussed what the different types of nutrients are and their basic functions in the body. They talked a little about the importance of vitamins A and C and discussed what foods would be good sources of those vitamins.

Next, they did the "Great Fruit and Vegetable Search." They were each given a lunch menu from their cafeteria and asked to identify the fruits and vegetables. Then they identified the fruits and vegetables that were good sources of vitamins A and C.

In the next part of the activity, the students took one of the fruits or vegetables from the menu and decided how many servings it counted as. Then they needed to determine how many other fruits and vegetables would need to be eaten at breakfast, as a snack or at dinner to get their 5 A Day.

Lastly, they went through the meal plan for the rest of the lunches that week and double-checked to make sure they got 5 or more servings of fruits and vegetables on that day. At the end of the class period, the students were given the post-assessment. In two of the sessions, they were able to enjoy the "5 A Day" song and get a little exercise by dancing or walking in place.

## **Northwest Juvenile Detention Center (Eau Claire, WI)**

### **Who?**

Students in the Northwest Juvenile Detention Center (16 students ages 10-17)

### **What?**

Presentation about the 5 A Day program and examples of serving sizes of each food group

### **When?**

Saturday, December 15, 2001

### **Where?**

Eau Claire, WI

### **Why?**

Children and adults are learning more about increasing the daily consumption of fruit and vegetables. To make us healthier, the average of five or more servings a day of fruits and vegetables is needed. Fewer than 15% of elementary students eat the recommended five or more servings of fruits and vegetables every day. Over half of all elementary students eat no fruit on any given day. Three out of ten students eat less than one serving of vegetables a day. One-quarter of all vegetables eaten by elementary students include french fries, a high fat, low nutrient vegetable option.

### **How?**

The presentation began with a display of food models representing the essential pyramid food groups. The models included a slice of bread, a box of rice, a gallon milk carton, a pork chop, cauliflower, a slice of pizza and a piece of apple pie. To make the presentation a bit real, a bunch of bananas and a few

red apples were added. The presentation began with an explanation of the 5 A Day program.

A lecture about the origin of the 5 A Day program was given. One of the greatest forces behind the 5 A Day program is the National Cancer Institute. About one-third of all cancer occurrences can be attributed to diet alone. Fruit and vegetable consumption has been consistent in showing a reduction of the risk of many cancers. The group talked about the importance of exercise and how it helps gain significant health benefits. Exercising 30 minutes a day and maintaining a healthier diet is one efficient way to control weight. Exercise uses extra calories that would be stored as fat. Exercise at the detention center includes playing basketball at least one hour every day.

A question about the nutrient content of pizza was posed because it contains four of the food groups (grain, vegetable, dairy and meat). Pizza could be a daily consumption of the essential food groups. The members proceeded to explain that pizza also contains lots of calories and fat. Other forms of the food groups need to be added.

The presentation was concluded with supermarket tips for proper selection of fruits and vegetables. These tips included: how to buy fruits at different ripeness levels, look for new products, add one fruit or vegetable to the weekly shopping trip, pick brightly colored fruits and vegetables and stock the freezer with assorted frozen vegetables for a quick addition to dinner.

## **Results**

### Gilman Elementary School (Gilman, WI)

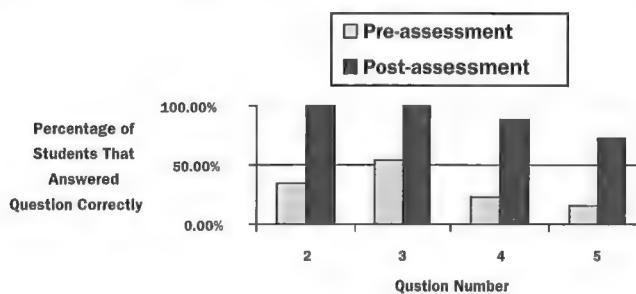
This project produced significant improvement in all areas of the evaluation criteria. Pre-assessment findings showed that six students (23.0%) were able to properly match food items to their location in the FGP. With one student absent, nine of 26 (34.6%) students correctly answered that one should eat at least 5 fruits and vegetables each day to keep healthy. Fourteen (53.8%) students correctly answered that phytochemicals give fruits and vegetables bright colors. Six (23.0%) students were correct when asked how long you should be active each day for good health. The pre-assessment results also recorded 4 (15.4%) students meeting the recommended intake of at least 5 servings of fruit and vegetables each day.

The post-assessment results were outstanding. The student absent from the pre-assessment did not take the post-assessment. Twenty-four of 26 (92.3%) students were able to properly match food items to their location in the FGP. All 26 (100.0%) students correctly answered that you should eat at least 5 servings of fruit and vegetables each day to keep healthy. In addition, every student (100.0%) knew that phytochemicals supply bright colors. Twenty-three of the 26 (88.5%) respondents correctly answered that you should be active 30 minutes each day for good health. Post-assessment results also recorded 19 (73.1%) students meeting the recommended intake of at least 5 servings of fruit

and vegetables each day. Seventeen of the 23 (73.9%) applicable students improved their daily fruit and vegetable consumption by 2 servings.

Figure 1 compares the percentage of students that answered pre- and post assessment questions 2-5 correctly. Questions 2-5: 2. How many fruits and vegetables should one have in a day? 3. Phytochemicals give fruit and vegetables their bright colors (answer was either true or false). 4. How many minutes of physical activity should be done in a day? 5. How many fruits and vegetables do you (the student) eat in one day (answering less than 5 was undesirable)?

Figure 1. Comparison showing the Percentage of Gilman Elementary 4th Grade Students Who Correctly Answered Pre- and Post-Assesment Questions 2-5.

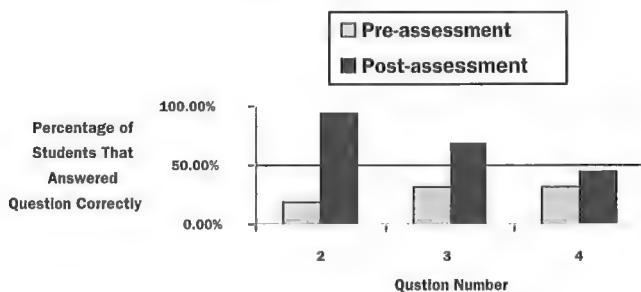


### Oaklawn Elementary School (Menomonie, WI)

A post-test was given to see if the discussion was helpful in understanding the 5 A Day program and the FGP. When comparing results of the pre- and post- assessments, a higher percentage of students correctly answered every post-assessment question. All students successfully matched foods to their appropriate FGP group. Fifteen out of 16 (93.8%) students correctly answered that everyone should have five to nine servings of fruits and vegetables a day compared to 3 (18.8%) in the pre-assessment. Eleven students (68.8%) correctly answered that phytochemicals give fruits their bright colors compared to 5 (31.3%) in pre-assessment. Seven (43.8%) students correctly answered that one should be physically active for 30 minutes every day compared to 5 (31.3%) in the pre-assessment.

Figure 2 on the next page compares the percentage of students that answered pre-and post-assessment questions 2-4 correctly. Questions 2-4: 2. How many fruits and vegetables should one have in a day? 3. Phytochemicals give fruit and vegetables their bright colors (answer was either true or false). 4. How many minutes of physical activity should be done in a day?

Figure 2. Comparison of Percentage of Oaklawn Elementary 2nd Grade Students Who Correctly Answered Pre- and Post-Assesment Questions 2-4



### United South Central Elementary School (Wells, MN)

In the pre-test, 55% of the students answered the question about "How many fruits and vegetables should you have in a day?" correctly. The post-test boasted a 97% success rate to the same question.

### Northwest Juvenile Detention Center (Eau Claire, WI)

Thirteen out of sixteen students correctly answered the question "How many fruits and vegetables should you eat in a day?" Everyone knew the answers pertaining to the FGP. Ten of the 16 learned that phytochemicals provide bright colors to fruits and vegetables and 13 students learned that they need 30 minutes of exercise a day.

## Conclusion

As a result of the educational sessions at Gilman Elementary, Oaklawn Elementary, United South Central Elementary and the Northwest Juvenile Detention Center, students learned about the importance of eating five to nine fruits and vegetables a day. The results suggest that an increase in knowledge of the 5 A Day program was successful through the chosen methods.

The hard work and dedication that went into this project will not be seen immediately. It is our desire that the information provided to the youth will be applied in their daily lives and passed down from generation to generation leading to decreased incidences of chronic diseases.

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# Detection of Methanotrophic Bacteria by DNA-DNA Hybridizations

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## Abstract

To investigate the abundance of methanotroph species in northern peatlands, we used DNA-DNA hybridizations against *Methylococcus capsulatus* and *Methylosinus trichosporium* (type I and II methanotrophs, respectively) to measure their presence in environmental and DNA samples. DNA extracted from pure culture, environmental samples, and clones were detected by slot-blotting, hybridization, and detection to see relative intensities. *M. capsulatus* and *M. trichosporium* probes annealed to their same control DNA; however, some non-specific detection also occurred. To detect these organisms in environmental samples, we tested the *M. capsulatus* and *M. trichosporium* probes against northern peatland DNAs. Our study appears to be a good measure of the relative quantity of methanotroph DNAs, and the environmental samples showed that methanotrophs are most abundant in the upper layers of the peat.

## Introduction

Methane is a powerful greenhouse gas that adds to global warming. As methane concentrations continue to rise it contributes more to global climate change than CO<sub>2</sub> (Lelieveld, Crutzen & Bruhl, 1993). Methane-oxidizing bacteria work to reduce these emissions. Methanotrophs play a key role in regulating atmospheric methane concentrations (Hanson & Hanson, 1996), but little is known about the species inhabiting northern peatlands. Understanding methanotroph ecology is essential for predicting and controlling future climate change.

Type I methanotrophs are found in the oxygenated peat surface, while type II methanotrophs are found in the reduced oxygen regions (Amaral & Knowles, 1995). Types I and II are based on differences in their internal membranes, phylogeny, carbon assimilation pathways, and fatty acid composition (Hanson & Hanson, 1996). *Methylococcus capsulatus* is a type I methanotroph and predominately grows in low methane/high oxygen regions, while *Methylosinus trichosporium* is a type II methanotroph that lives best on low oxygen and high methane concentrations (Amaral, Archambault, Richards & Knowles, 1995; Amaral & Knowles, 1995).

This study explains the distribution of *M. capsulatus* and *M. trichosporium* methanotrophs in northern Minnesota peat bogs. Hybridization tools were also used to screen a clone library for diversity of methane-oxidizing bacteria.

DNA-DNA hybridizations were used to reveal not only probe response to controls DNAs but also probe response to environmental DNAs from the Minnesota peat bog. Embedded in a membrane, the DNAs were hybridized to see if they were identical to or closely related to *M. capsulatus* or *M. trichosporium* methanotrophs. The study showed *M. capsulatus* and *M. trichosporium* were most abundant in the top and middle depths (0-40 cm), but least abundant in the bottom depths (40-60 cm).

## Materials and Methods

### Sampling Site

Environmental peat samples were taken from Hole in the Bog Lake in northern Minnesota, 47°18.661' N, 94°13.165' W. The samples were taken at an elevation of 1,200 ft and an air temperature of 22°C. The water had a temperature of 15°C, a pH of 6.84, and an oxygen content of 3 ppm at a water depth of 10 cm. Peat samples were taken at 0-20cm, 20-40cm, and 40-60cm depths using a stainless steel corer. Core samples were aseptically placed in 50 ml Falcon tubes and transported to the laboratory in a cooler on dry ice. Samples were stored at -20°C until further analysis.

### DNA Extraction From Environmental Samples

Lysozyme was added to lyse the peat samples and incubated according to the DNA extraction protocol (McDonald, et al, 1999). To separate macromolecular classes, the samples were centrifuged and supernatant was collected. The pellet was re-suspended in extraction buffer and proteinase K, then incubated. The samples were centrifuged, and supernatant was combined with the previous. The pellet was re-suspended in extraction buffer and centrifuged. The supernatant was removed to a clean tube and refrigerated overnight to precipitate the DNA. The samples were centrifuged to harvest the DNA. The remaining pellet was suspended in TE buffer, which contained the DNA for ultra-centrifugation purification.

The DNA was purified by ultra-centrifugation and ethidium bromide was removed by washing with isoamyl alcohol according to the protocol (Sambrook & Russel, 2001).

### DNA Extraction From MOB Pure Cultures

Pure cultures of *M. capsulatus* and *M. trichosporium* cells were harvested by centrifugation at 10,000 rpm for 20 minutes at room temperature (Sorvall SA-600). DNA was extracted from the cell pellet according to the protocol (Sambrook & Russel, 2001). The pellet was suspended in TE buffer (10 mM Tris + 1 mM EDTA), lysis buffer components were added and cells were incubated at

37°C for 20 minutes. Proteinase K was added and cells were incubated at 50°C for 1 hour with periodic mixing. The lysate was cooled and phenol/chloroform/isoamyl alcohol (25:24:1 v/v/v) was added, and the mixture was centrifuged at 10,000 rpm for 15 minutes at room temperature. The top layer containing the DNA was transferred to a new tube and the DNA was precipitated by the addition of 0.1 volume 10 M ammonium acetate and 2 volumes ethanol. DNA was harvested by centrifugation (15,000 rpm for 15 minutes at room temperature) and washed with 100% ethanol. The resulting pellet was dissolved in 1.0 ml TE buffer.

### DNA Extraction from Clones

16S rRNA genes were amplified from the samples collected above using two methanotroph-specific primers (Mc for *Methylococcus* and Ms for *Methylosinus*). These diverse PCR products were cloned according to instructions in the TA cloning kit (Invitrogen, Carlsbad, CA). Cloned DNAs were purified using the Wizard DNA clean-up system (Promega, Madison, WI). To assess whether the cloned sequences were related to *Methylococcus* or *Methylosinus* spp., cloned DNAs were hybridized to the probes constructed as described below.

### Probe Construction

The *M. capsulatus* and *M. trichosporium* probes were constructed using the PCR DIG Probe Synthesis Kit (Roche, Mannheim, Germany). The Primers were provided by a laboratory supply company. A polymerase chain reaction was used to synthesize a probe that targets the 16S rRNA. Primers Ms1020 and Mc1005 were paired with a universal primer (F27) and digoxigenin labeled nucleotide are incorporated into the PCR product. This PCR product was checked for proper size by running 5 $\mu$ l of the sample on a 1% agarose gel.

### DNA Hybridization

#### DNA Slot-blotting

The DNA samples (environmental DNA, cloned PCR products, or MOB pure cultures) were denatured by boiling for 10 minutes followed by rapid cooling in an ice water bath. The amount of DNA used for each sample ranged from 0.1 – 10 ug. The Bio-Dot apparatus was assembled according to manufacturer's instructions (Bio-Rad, Hercules, CA). TE buffer was added to each well and aspirated, followed by the samples and 0.4 M NaOH. The blotted membrane was rinsed in 2X SSC, air dried and exposed to UV-light to cross-link the DNA to the membrane.

#### Hybridization

A recirculating water bath was equilibrated to the appropriate hybridization temperature (56°C). Membranes were pre-hybridized with a pre-mixed

hybridization buffer, DIG Easy Hyb (Roche) (20ml/100cm<sup>2</sup> of membrane) and incubated according to the Bio-Dot SF Microfiltration Apparatus Instruction Manual (Bio-Rad). The probe (5µl) was denatured as above and combined with DIG Easy Hyb (3.5ml/100cm<sup>2</sup> of membrane). The pre-hybridization mixture was removed from the bag containing the membrane and the probe mixture was added to the membrane. The sealed bag was placed in the 56°C water bath overnight. The membrane was removed from the bag, rinsed in 2X SSC + 0.1% SDS (w/v), covered in 0.1% SSC + 0.1% SDS, and placed in a 68°C recirculating water bath for 15 minutes to remove unbound probe.

#### DIG Nucleic Acid Detection Kit

The membrane was briefly rinsed in washing buffer and incubated in blocking solution, followed by antibody solution using the DIG Nucleic Acid Detection Kit (Roche). The membrane was placed in washing buffer and equilibrated in detection buffer. The membrane was incubated in color substrate solution until the color reaction developed. The reactions were stopped by placing the membrane in TE buffer and allowing it to dry.

Hybridization band intensities were measured by the eye and rated on a scale from zero to four (four being the strongest). The relative hybridization intensities were calculated by subtracting the *Methylosinus* probe response from the *Methylococcus* probe response.

### Results

To test the specificity of the *M. capsulatus* and *M. trichosporium* probes, we annealed the probes to their same control DNA and other non-related species. This was done by running a DNA hybridization that optimized probe annealing to its own DNA, while minimizing annealing to non-specific DNA. As stated, optimization of the probe annealing was done by increasing its temperature. Figure 1 shows that the *M. capsulatus* probe annealed strongest to its own DNA, but also to DNA from the methanotrophic species like *Methylomicrobium album* and *Methylomonas methanica*. It also appeared to anneal to a non-methanotrophic species, *Ralstonia eutropha*. The *M. trichosporium* probe annealed most strongly only to its own DNA (Fig. 1).

To detect the relative abundance of these organisms in environmental samples, we tested the *M. capsulatus* and *M. trichosporium* probes against northern peatland DNAs. The probes were used to see if different populations of methanotrophs exist at different depths. Figure 2 shows that both probes annealed strongly to the top samples, weakly to the middle samples, and did not anneal to the bottom samples. The more concentrated DNAs also showed stronger annealing (Fig. 2).

The relative hybridization intensities for the clone probing experiment appear in Table 1. The clones at the top of the table hybridized most intensely to the *M. capsulatus* probe, while the clones at the bottom of the table

hybridized most intensely to the *M. trichosporium* probe. Although the Ms primers (specific to *Methylosinus* spp.) amplified PCR products that hybridized most intensely with the *Methylosinus* probe (relative intensities of -1 to +1), the Mc primers amplified DNA that hybridized to a larger range of Mc probe intensities (0 to +3). Figure 3 illustrates this relationship. More clones amplified with the *Methylosinus* primer hybridized most intensely to the *Methylosinus* probe. However, clones amplified with the *Methylococcus* primer hybridized over a wider range of intensities.

## Conclusions

Our experimental protocol appears to be a good measure of the relative abundance of methanotroph DNAs. The *M. capsulatus* and *M. trichosporium* probes annealed to their own DNA. The hybridization shows that *M. capsulatus* is concentrated because of the intense color in the well. It also anneals to other control DNAs indicating that it may not be as specific as the *M. trichosporium* probe. *M. trichosporium* anneals to its own DNA and the hybridization clearly shows that it does not hybridize to the other control DNAs. The difference of intensity between the two probes may be that the *M. trichosporium* probe is weaker, or less sensitive than the *M. capsulatus* probe. This weakness may be due to lower incorporation of the DIG moiety during probe synthesis.

The environmental hybridization shows that methanotrophs are most abundant in the upper layers of the peat. This may be due to the presence of oxygen and methane in the top layers. These are substrates for methanotroph physiology, so in order for methanotrophs to oxidize methane, both methane and oxygen must be present. Since oxygen levels decrease as depth in the peat increases, methanotrophs are most likely to be found in the surface layers.

All of the clones hybridized to either the *M. capsulatus* or the *M. trichosporium* probes. Figure 3 illustrates that the Ms PCR primers are much more specific to *Methylosinus* sequences than the Mc PCR primer is specific to *Methylococcus* sequences. Ideally, the Ms clones would all have a relative intensity of +1, indicating that the primers only amplify *Methylosinus* species and that the probe is specific. Since we observe a range of relative probe intensities, we must conclude that a diversity of *Methylosinus* sequences were amplified. In contrast, the *Methylococcus* clones a wide range of hybridization intensities, indicating that a diversity of species is amplified with this primer.

Figure 1. Probe response to control DNAs.

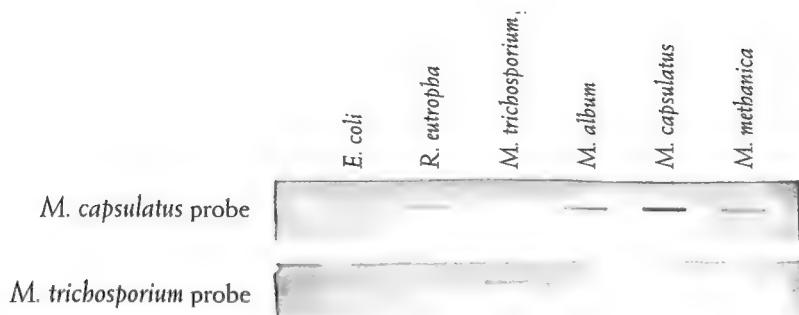


Figure 2. Probe response to environmental DNAs from Minnesota peat bog.  
Depths: Top (0-20cm), Middle (20-40cm), Bottom (40-60cm).

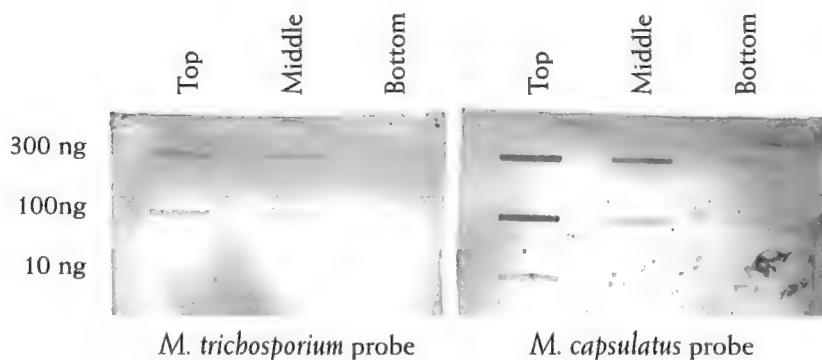
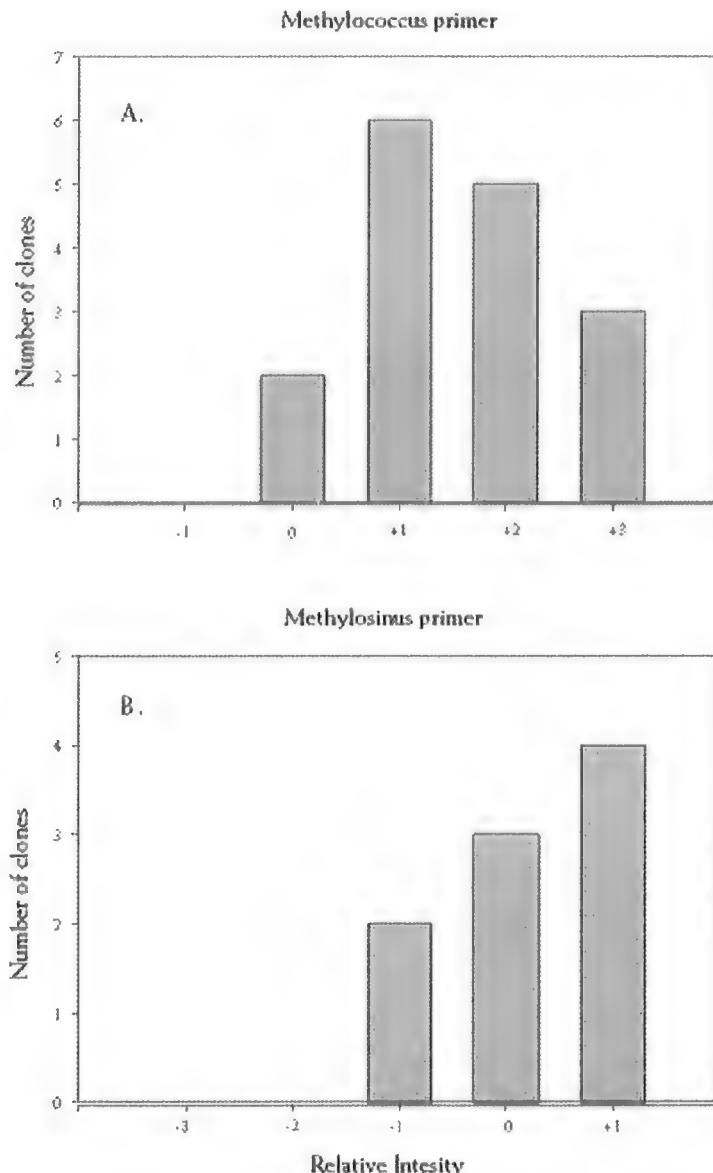


Figure 3. Number of clones displaying the given relative hybridization intensity and amplified with PCR primers *M. casulatus* and *M. trichosporium* appear in plots A and B, respectively.



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# **Metall:X in the Treatment of Arsenic in Hazardous Wastewater from the Production of Gallium Arsenide Wafers**

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## **Introduction**

Arsenic, a known carcinogen as well as a potential teratogenic agent (causing developmental malformations), has been found to cause negative effects on humans such as skin and lung cancer. From an environmental exposure standpoint, populations that utilize water near geologic or man-made sources of arsenic may incur numerous health problems as a result of receiving higher than typical doses to the arsenic (CrossRoads, 2001). It is highly likely that industrial-based exposures occur in addition to those that take place from an environmental standpoint.

Arsenic exposure is a concern in the semiconductor industry, which is shifting from silicon to gallium arsenide wafers due to its capacity to move electricity faster and rare ability to generate light impulses. Water used for cooling during the cutting and grinding phase of wafer development becomes contaminated with soluble arsenic and consequently, must be treated as hazardous waste (SolmeteX: Applications, 2001). Such water contamination can be significant in light of the fact that a single large semiconductor manufacturing plant, producing 5,000 eight-inch wafers a week, could consume as much water as a small city (O'Meara, 2000). While use minimization as well as effective treatment of arsenic-laden water would likely be of great environmental concern to a semiconductor manufacturing company, it is probable that the legal and financial repercussions associated with such are also significant.

A common treatment method for arsenic requires the microfiltration of the wastewater with 0.1 um membrane followed by ion exchange resin and/or ferric/sulfate co-precipitation which culminates with a final microfiltration. Because the level of arsenic reduction achieved by this method is below acceptable government/municipality-based discharge levels, the wastewater must be taken to a treatment facility for further processing. In addition to the issue of not reducing the concentration of arsenic in the wastewater, the spent resin also has to be treated as hazardous waste and removed to a company permitted to handle hazardous waste (SolmeteX: Applications, 2001).

Of all the companies specializing in various types of wastewater treatment process products that are intended to improve the treatment of arsenic, one organization by the name of SolmeteX appears to stand out with its innovative

products. The Solmetex process for arsenic removal, which can be treated at the point of generation during the wafer cutting process or with a main facility treatment system, is made of three major components. In the primary step, mild oxidation is used to remove iron and manganese, which leads to the formation of hydroxides that remove soluble arsenic by precipitation or adsorption reactions. In the secondary treatment step, pre-micron filtration is used to remove large particulate matter. For the tertiary phase, beads of Metall:X are used to adsorb soluble arsenic in flow-through columns. Flow-through columns are simply a series of 55-gallon drums filled with Metall:X resin beads. The untreated arsenic-contaminated water runs through the top of the first 55-gallon drum. Once the water reaches the bottom of the drum, the liquid is pumped to the top of the second 55-gallon drum and the cleansing process is repeated. Finally, a post-micron filtration step is used to remove any remaining arsenic particles (SolmeteX: Applications, 2001).

Metall:X is a resin-based material that targets specific metals and is able to adsorb such materials at flow rates of 10 to 30 gallons per minute per 55-gallon, drum depending on the arsenic concentration within the contaminated water. The beads bind a targeted metal, such as arsenic, so tightly that average levels left in the treated water are below 10 parts per billion (ppb), meeting EPA's current permissible amount of 10 ppb of arsenic in drinking water. This process allows the nearly pure arsenic metal to be recovered, by pH adjustment, for potential reuse instead of sending it to landfills as hazardous waste (SolmeteX: Company Information, 2001). The relatively clean water may be either discharged back into the wafer cutting process or to a municipal treatment facility. Thus, various benefits of Metall:X use are in evidence, but a thorough risk analysis of Metall:X has not yet been completed to determine the positive and negative impacts on semiconductor company assets.

## **Purpose**

The purpose of this study is to question if Metall:X should be the product of choice for arsenic remediation after all risks to semiconductor industry assets have been explored.

## **Goals**

- Analyze the Metall:X adsorption-based process for arsenic removal in the primary risk control areas associated with people, environment, product, materials, facility, equipment, public, and legal-based assets.
- Identify areas of further investigation to determine appropriateness of Metall:X use.
- Determine feasibility of treated gallium arsenide wastewater being reused or recycled back into the fab production.

## Methodology

- Review the water requirements associated with cutting gallium arsenide wafers through a literature review of articles and journals as well as contact with outside professionals.
- Analyze the positive as well as the negative aspects of Metall:X concerning potential company assets though personal contact with Solmetex representatives and review of information that the company provides.

## Limitation

A limitation of this study is the minimal information that is currently available concerning the use of Metall:X.

## 1. People

One of the first considerations when bringing in a new product or chemical should be that of its effects on the people working with and around said material. Concerning Metall:X, there are identifiable benefits as well as disadvantages that are likely to exist as they relate to utilizing this product.

### 1.1 Benefits

With the use of Metall:X, since it is a fully contained system, it is likely there would be less direct labor requirements than treatment methods that need periodic maintenance. This would decrease costs in the way of wages and allow for employee reassignment to other areas, new divisions or those lacking appropriate workforce.

### 1.2 Disadvantages

The disadvantages of Metall:X can be broken down into two categories, the health effects and new process considerations.

#### 1.2.1 Health Effects

Metall:X comes in powder and granular form, of which both produce a certain amount of dust when being handled. This dust may cause mechanical and/or chemical irritation when it comes into contact with mucus membranes and skin. If inhaled, Metall:X may start an exothermic reaction, which could then result in a type of heat-based burn on the lung's mucus membrane.

Personal protective equipment requirements include a particulate respirator, gloves, and safety glasses. Metall:X may evolve carbon dioxide when heated in oxygen-deficient conditions, which may become a respiratory concern in an enclosed environment.

#### 1.2.2 New Process Considerations

Bringing in a new treatment method will require training of maintenance, direct treatment supervisors, and anyone else associated with the treatment of arsenic using Metall:X. This training will take time and money to be effective. Also, as mentioned in the benefits, the relocation of employees due to possible

displacement may have negative connotations as well. Employee displacement may leave certain individuals feeling demoted or unnecessary. Efforts to explain and understand employee concerns should be provided if displacement becomes necessary.

### **1.3 Areas of Further Investigation**

#### *1.3.1 Ergonomics*

There are areas that, as a risk control professional, one should further investigate. The potential ergonomic issue could cause some concern. The treatment system is contained in 55-gallon drums, but the replacement Metall:X resin beads or powder containers may prove awkward, unwieldy, or heavy, resulting in back strain or cumulative trauma disorders. Another ergonomic issue would be the manual removal of the hydrated Metall:X. Lifting and twisting may create back problems that might accumulate over time, thus leading to a serious back injury that could result in large workers compensation claims. These ergonomic issues may be resolved through automation of the Metall:X transfer, both into and out of the 55-gallon drums.

#### *1.3.2 Exposure*

Before bringing a new product or chemical on site, exposure-related health effect information should be ascertained. For Metall:X specifically, there is the question of the severity of health effects if contact should occur. The Metall:X material safety data sheet (MSDS) lists first aid measures and mentions consultation with a physician for eye contact, skin contact, inhalation, and ingestion. Also, exposure to arsenic-contaminated Metall:X may be of concern. Arsenic is a known carcinogen and a company should determine if it is possible to become exposed through various modes of transportation or handling practices.

## **2. Environment**

With government regulations, semiconductor companies are required to treat chemicals for various fab processes. For arsenic in particular, the EPA has recently (as of 1/02) lowered the safe drinking water level to 10 ppb. A treatment system, be it on site or off, needs to treat at or below this level, where previously it could be treated to 50 ppb.

### **2.1 Environmental Benefits**

Solmetex, the manufacturer of Metall:X, claims that arsenic is removed to levels below 10 ppb. Arsenic can then be recovered, through pH adjustment, from Metall:X, which would reduce material costs (Solmetex, 2001). Since arsenic is being removed to levels below the EPA Safe Drinking Water standard, direct discharge of treated effluent to water sources is possible if the water is not going to be circulated back into the system. Direct discharge of the treated water into the environment would limit the volume going to the general wastewater treatment facility, thus unnecessarily treating "clean" water.

In addition to cleansing water of arsenic, Metall:X also removes other chemicals and metals from process effluent. Solmetex states that Metall:X has successfully removed substances such as ferro-cyanide complexes, carbonate, silver thiosulfate, phosphate, molybdenum, chromium, sulfate, selenium, copper and nickel citrate complexes, and copper and nickel EDTA complexes. A possible benefit to this multi-treating substance is that if there are other processes that need to be treated for any of the substances mentioned, all effluent can be directed to the same treatment system to be simultaneously treated. Thus, treatment costs may be reduced by using a single treatment system for several chemicals instead of having a different treatment system for each substance.

## 2.2 Disadvantages

As mentioned in the Metall:X material safety data sheet (MSDS), when the product comes into contact with water, an exothermic (heat producing) reaction occurs. If this product should get out into the environment, such as into a river or lake, a reaction would be likely to have some negative effects. Consequently, ecosystems may be irreparably damaged if Metall:X came into contact with them.

Arsenic is a recognized carcinogen, but little is known about arsenic's specific cancer causing properties. Consequently, the EPA's lowering of the Safe Drinking Water level to 10 ppb may not be adequate in the future when more information is uncovered regarding arsenic and its negative health effects on the human population. Since Metall:X is advertised as treating arsenic-contaminated water to levels below 10 ppb, it appears to be an adequate arsenic treatment, but if the EPA Safe Drinking Water standard should be lowered in the future, it is unlikely that Metall:X alone would be a sufficient treatment methodology.

## 2.3 Areas of Further Investigation

### 2.3.1 Effects on Public Water

Metall:X is a product just recently making an appearance in the treatment market. Very little scientific study has been done on the product and its effects on the environment. Before deciding on such a product with such potential to do environmental harm, the effect on surface and ground water ecosystems should be analyzed. Not only is this an environmental issue, but a public concern as well.

### 2.3.2 Disposal

The question of used-product disposal also needs to be determined before using a product such as Metall:X. As mentioned, arsenic may be recovered from the resin powder or beads, but effectiveness of the removal needs to be determined. The amount of arsenic remaining on Metall:X before disposal needs to be ascertained. If arsenic is still present on the Metall:X resin, the question of feasibility for landfill disposal (as advertised) needs to be answered.

An exothermic reaction may be possible if water or acid should come in contact with the arsenic-reclaimed Metall:X in the landfill. Solmetex states that spent Metall:X has passed the Toxicity Characteristics Leaching Protocol (in order to be disposed of in a landfill) for many applications, but gives no examples or data to support such a claim. Disposal is a definite concern that needs to be looked at before utilizing a new treatment process.

### **3. Product & Materials**

The use of Metall:X could have a profound impact on benefiting or hindering the production of semiconductor products. The benefits include ways of reducing production costs while the disadvantages involve possibly reducing product production.

#### **3.1 Benefits**

One way of reducing production costs is to minimize material wastes. If arsenic can be recovered from Metall:X then it is possible to reuse that arsenic. The reclaimed arsenic may need to be processed by another company who could then supply the arsenic in its needed form.

Another potential cost reduction strategy associated with using Metall:X is the possibility of utilizing it in a closed-loop water system. Reusing the treated wastewater either in the wafer cutting and grinding process or in another area would reduce water costs. Various figures state that it takes 1500 gallons of water to process a single 8" wafer (Allen and Hahn, 1997) or 500 gallons per minute to process 480,000 200-millimeter wafers. Required water amounts result in expenditures of several millions of dollars (Veltri, DeGenova, O'Hara, and Airth, 2000). If it is possible to recycle, reuse, or redirect some of the treated water, cost savings could pay for the new treatment system in a few short years.

#### **3.2 Disadvantages**

From a disadvantage standpoint, the use of Metall:X may limit product production through fixed system limitations. If the treatment process cannot keep up with the wafer production process, something needs to give. Either the wafer production would need to be limited in order to accommodate the treatment capabilities (loss of production), or the treatment system would need to be expanded to accommodate production (increase in equipment costs). Production requirements need to be considered when looking at the Metall:X system since each drum is designed to treat flow rates up to 10 gallons per minute.

#### **3.3 Areas of Further Investigation**

Areas that need further investigating as they relate to the area of product and materials include cost of arsenic reclamation, cost of a closed-loop water system, and any electricity demands that the treatment process might require.

## 4. Facility & Equipment

The use of a new treatment system and product, such as Metall:X, will likely cause facility concerns due to space, handling, storage, and hazard potential. Thus, each aspect needs to be examined before purchasing and installing a new treatment system.

### 4.1 Benefits

Based on the Metall:X material safety data sheet, Metall:X is a non-combustible material with no flash point or flammability limits. Thus, there is little fire hazard associated with the product. Solmetex also claims that Metall:X is stable under normal conditions.

### 4.2 Disadvantages

#### 4.2.1 Storage

Dry storage is required for the Metall:X product due to its high potential to cause an exothermic reaction when mixed with water. Also, acids cannot be stored around Metall:X due to the same potential exothermic reaction. This may be of great concern in an industry where the prevalence of water and acids (which look alike) are quite high.

#### 4.2.2 Ventilation

The powder or granular form that Metall:X comes in may result in the present ventilation system not being adequate to remove the associated dust from the treatment area. Consequently, a new or modified ventilation system may be required to prevent excessive dust exposure to workers. A dust build-up due to inadequate ventilation and maintenance may also result in a dust explosion, if an adequate ignition source is present and has a high potential for damage.

#### 4.2.3 Equipment

As a result of switching to the use of Metall:X, it is probable that new treatment equipment would need to be installed. As a result, the question of compatibility should be answered before purchasing new treatment equipment. Not only would new equipment be brought in, but the disposal of the previous treatment system would likely be an issue, especially if the previous system was contaminated with arsenic or another toxic chemical. Along with the installation of new equipment would be the need to revise the means used to handle/dispose of arsenic-contaminated Metall:X as well as address various maintenance requirements.

#### 4.2.4 Explosion Potential

As mentioned before, Metall:X is stable under normal conditions, but abnormal conditions may occur that might reduce Metall:X's stability. Due to Metall:X's inherent exothermic reaction to water, if the wafer production is halted and water flow stopped, there is the possibility of a pressure explosion from the steam being created in a closed container. Not only would this be a

hazard to workers but also to the entire treatment system. Thus, certain engineering as well as administrative-based precautions would need to be taken to prevent the occurrence of an explosion.

#### **4.3 Areas of Further Investigation**

In light of the fact that information/data concerning Metall:X tended to be rather scarce, areas that would require more in-depth knowledge concerning the facility and its equipment include the size of the system compared to the available facility space, efficiency and cost of new equipment, and maintenance requirements.

##### **4.3.1 Size**

Since every 55-gallon drum treats 10 gallons per minute of effluent, the wafer production output would determine how many drums are needed. Such being the case, space considerations would then have to be taken into account. Only a certain number of drums may fit in a designated space (different for every fab). If the wafer production is on the smaller side, space/size limitations would be of little concern. Those semiconductor companies who produce gallium arsenide wafers in large quantities may have a space issue concerning Metall:X treatment.

##### **4.3.2 Efficiency and Cost of Equipment**

The question of efficiency comes into account when comparing the use of Metall:X to any previous treatment method. If the previous treatment meets standards (i.e., possesses a comparable efficiency), then the cost of the new treatment system may be the deciding factor. If using Metall:X is more efficient in removing arsenic from wastewater than the previous treatment method, then both cost and efficiency capabilities may be used as a deciding factor. Cost of the new equipment may or may not be justified through the treatment and reclamation of arsenic. A cost/benefit analysis should be performed to determine the financial viability of using Metall:X as a new treatment process. Such an analysis could determine the amount of time it would take to pay for the new treatment system.

### **5. Public**

Like the environment, the public is an off-site area where a company should analyze risks posed by the use of Metall:X. This is especially important in a time when the public appears to highly scrutinize the manufacturing firms that are present in the community.

#### **5.1 Benefits**

The manufacturer's literature indicates that the process of utilizing Metall:X to treat arsenic-contaminated water significantly lowers the arsenic level in water effluent, making it suitable for direct discharge into drinking water. Thus, the public is unlikely to be exposed to excessive levels of arsenic from

the fab's wastewater discharge. Secondly, the act of notifying/educating the public on various steps being taken to prevent public arsenic poisoning creates good public relations with the surrounding community, an activity that can significantly benefit the company in the future.

## 5.2 Disadvantages

The disadvantages of using Metall:X compound to the public-based assets need to be further investigated to determine the extent of the effects. The consequences if the treatment system failed need to be ascertained in order to take the necessary steps to prevent such an occurrence. The consequences of a public arsenic-reclaimed or arsenic-contaminated Metall:X spill need to be explored. The effect on people if the arsenic-reclaimed or arsenic-contaminated Metall:X somehow got incorporated into drinking water needs to be examined. These contamination issues should be understood in case some accident did occur in the transportation of the used product, or if the untreated effluent was directly discharged into a water source.

## 6. Legal

As with the adoption of any new material/process, the legal ramifications need to be explored before utilizing Metall:X. The benefits revolve around meeting government agency requirements while disadvantages associated with improperly managing a process that utilizes Metall:X could include lawsuits, contamination accountability, and future stricter standards.

### 6.1 Benefits

Governmental agencies dictate standards that the use of Metall:X can help meet. Due to using Metall:X to treat for arsenic, the EPA Safe Drinking Water standard could be met and no fines would be incurred due to excessive arsenic levels occurring in treated wastewater. Not only can Metall:X treatment help on the front-end of the arsenic treatment process, but it may also help to reduce fines already incurred if the new treatment system is implemented in a timely manner. While the current research appears to be insufficient concerning either the environmental or health effects of arsenic, further studies may provide more insight, and thus, it may lead to gaining grants or funding for researching arsenic and the effectiveness of Metall:X arsenic treatment.

### 6.2 Disadvantages

If a contracted hauler should spill used Metall:X, the accountability would ultimately fall back to the semiconductor company that originated the waste. If a spill should occur, a quick response would be necessary to minimize environmental contamination issues as well as the possibility of civil action lawsuit-based repercussions. The possibility of more strict future Safe Drinking Water standards is of legal concern as well as public spills. If Safe Drinking Water

standards become stricter, but the current treatment system cannot meet those standards, legal issues might arise, especially if fines are involved due to EPA violations.

## **Conclusion**

After examining the known/identifiable benefits and risks to all assets of a semiconductor company, a decision on the potential new treatment system utilizing Metall:X was not reached due to several areas that need further investigation. From gathered information, Metall:X appears be a product worth researching as a new arsenic treatment methodology. Other adsorption-based products on the market may or may not compare to the benefits of Metall:X. From the information available, the researcher believes that Metall:X could benefit a smaller gallium arsenide wafer producing fab, but not as a stand-alone process. Adsorption process (like Metall:X) coupled with other treatment methodologies would be the best way of assuring that all arsenic (in various forms) will be removed from contaminated water as a result of gallium arsenide wafer production.

It is well known that water use minimization and generation of contaminated water are significant issues in the semiconductor industry. The achievability of recycling the treated water into the wafer cutting and grinding process is attainable if the soluble gallium and gallium particulates were recovered as well. This is only possible if gallium and arsenic are the only contaminants in the wastewater effluent. Thus, point of use treatment would be recommended for both arsenic and gallium reclamation. There are gallium reclamation processes currently available. Like the recovery of arsenic, the recovery of gallium would reduce material costs, since gallium is valued at more than \$500 per kilogram (Travis, 2002). An area for further research is a comparison between the Metall:X adsorption method and other adsorption-based products currently on the market.

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# An Analysis of Competencies Performed by Administrative Professionals for the Administrative Assistant Degree Program at Chippewa Valley Technical College (CVTC)

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## **Statement of the Problem**

Chippewa Valley Technical College (CVTC) needed to determine competencies performed by administrative professionals for the purpose of updating its Administrative Assistant degree program and curriculum. The most recent formal competency study, a DACUM (developing a curriculum), for the program was completed in April 1994.

### **Justification for Research**

1. Due to the rapid growth and development of technology and use of information in business, administrative professionals must be proficient at understanding and utilizing technological innovations and perform higher administrative and informational functions than they have in the past. Administrative professionals cannot be negligent about learning or using new technology or software. In fact, administrative professionals should be proactive in the areas of informational and technological literacy in order to be successful in the field. Therefore, it is necessary to study which technological advancements are being utilized in offices so that administrative professionals and students can be adequately prepared to use these innovations.
2. Data from this research will assist the Business Technology Department in determining which competencies to include within the Administrative Assistant program and to determine if a program revision and/or name change is warranted. The information gathered is critical to support the development of progressive, new curriculum and program changes within the department.
3. The data generated will justify the budgeting for updated and additional equipment purchases to aid instructors in delivering courses and in order to maximize relevant student learning.
4. The data provided by this research is also necessary to accurately assess

student learning within the Administrative Assistant program at CVTC.

5. This research will help the Business Technology Department maintain conformity with the mission statement of CVTC by insuring that the Administrative Assistant degree program satisfies the workforce demand of businesses in the region.
6. This study will address the concern among individuals in the clerical profession and instructors in this area about removing the stereotype of "secretary" and justifying a Wisconsin Technical College System program revision and/or title change.

### Significance of the Study

This study is important to administrative professionals and technical education for the following reasons:

1. This study reinforces the partnership between Chippewa Valley Technical College and businesses within the region.
2. This study strengthens the relationship between the Wisconsin Technical College System and businesses within the state.
3. The Chippewa Valley Technical College Administrative Assistant program will be more attractive to potential students for the purpose of increasing and updating professional skills. This will assist in attempts to increase enrollment in the program.
4. The faculty teaching in the Administrative Assistant program at Chippewa Valley Technical College will be provided opportunities for staff development to continually update their knowledge and expertise of current business practices and technologies.
5. Other technical colleges across Wisconsin can use this data to update their programs.

### Summary

The purpose of this research was to provide data for the Administrative Assistant degree program at Chippewa Valley Technical College. After a review of literature, a questionnaire was developed and pilot tested. The purpose of the questionnaire was to identify job competencies of administrative professionals, determine present and future software and technology needs for the profession, and identify present and future job titles of administrative professionals in the west central Wisconsin area. Two groups were surveyed within the Eau Claire region. The populations surveyed included attendees from the 2000 and 2001 International Association for Administrative Professionals (IAAP) Office Personnel Seminars, the mailing list for the UW-Stout Administrative Professionals luncheon, and attendees of the 2001 UW-Stout Administrative Professionals luncheon.

Survey data was analyzed using SPSS software. A report of frequency counts, percentages, mean, and standard deviation were generated. Cross tabu-

lation reports of frequency counts and percentages between the different survey groups and demographic groups were also printed. Finally, cross tabulation reports of frequency counts and percentages of the collapsed demographic groups were created. Data in the report were presented and discussed according to the sequence of the survey instrument.

## Conclusions

There were four research objectives addressed by this study. Each objective will be restated and conclusions made for each.

**Research Objective Number One:** Identify administrative assistant competencies in the Eau Claire region.

The study identified specific competencies that are currently being performed by administrative professionals working in businesses in West Central Wisconsin. A thorough listing of competencies was identified and ranked in order of performance by administrative professionals.

Many of the competencies traditionally thought of as administrative assistant duties, are overwhelmingly still performed by administrative professionals. The results confirmed that administrative professionals are responsible for performing a variety of organizing and planning functions within the company, maintaining equipment and supplies, managing records and files, distributing information, and producing a vast assortment of documents. Furthermore, administrative professionals must have excellent communication skills because of their interaction with clients, colleagues, and the community.

The role of administrative professionals is changing and responsibilities are increasing as documented by the review of literature and the survey conducted. Although the performance ratings for some of the competencies were rather low, respondents were nevertheless indicating some performance of all of the job responsibilities identified in the survey instrument. In other words, for administrative professionals in this region, a few of the tasks may not be considered normal or recurrent job duties, but those competencies are still being performed. Administrative professionals may be called upon to perform such responsibilities for a special project, in the absence of a co-worker, or based on the size of the organization or type of business. Therefore, the identification of any and all competencies being performed is an indication of a training need. Consequently, the Business Technology Department within Chippewa Valley Technical College was able to update its Administrative Assistant degree program and curriculum based on this study.

**Research Objective Number Two:** Determine the present and future software and technology needs of administrative professionals in the Eau Claire region.

The study also verified the present software and technology needs of

administrative professionals in the Eau Claire area. Administrative professionals are currently using CD read/write (CD-RW) drives, scanners, digital cameras, meeting software, and forms software more than some of the other progressive technologies and software. Many administrative professionals are conducting Internet research and some are responsible for designing and updating web pages. However, evidence gathered suggests that use of advanced and innovative software applications by administrative professionals is not prevalent. Depending on the type and size of the organization, administrative professionals are required to use a variety of technologies and software applications in the performance of their job functions. Although some innovative technologies like computer pens and personal digital assistants or advanced software such as voice recognition are not widely being used by administrative professionals at the present time, the technologies themselves may still be emerging, transforming, and improving.

The future software needs of administrative professionals as indicated by this study are software applications that aid in the performance of accounting functions, desktop publishing, web page design, project management, as well as meeting and forms software. The expected technology needs of administrative professionals included digital cameras, personal digital assistants, and CD-RW drives.

Further technological maturity as well as informed knowledge about how innovations and advanced software can be used in business will inevitably merge the technologies uncovered by the review of literature into the typical responsibilities of administrative professionals. Moreover, administrative professionals surveyed may not be directly involved in long range planning efforts within their organization and therefore, may not have first-hand knowledge about the implementation of advanced software and innovative technology.

#### **Research Objective Number Three: Identify present and future job titles of administrative professionals in the Eau Claire region.**

The study identified present job titles and explored the preferred use of contemporary and progressive job titles for this occupation. The results established that administrative professionals work under a variety of different job titles.

Within the category of government, being most identified by participants, it is not surprising that traditional job titles of secretary, program assistant, administrative assistant, and clerk were prevalent. It was surprising that no consensus on a preferred job title other than administrative assistant for this occupation could be reached. One explanation could be that since the job titles are mandated by government classifications, changing them would be difficult and would require a statewide transformation. Another rationalization might be that individuals in this occupation are not as concerned about the professionalization of job titling or the image of professionalism as the administrative profes-

sion itself is. Overall, respondents were not dissatisfied with the title of administrative assistant. As a result, there was no consensus on a preferred job title for this occupation.

**Research Objective Number Four:** Determine if there is a difference in administrative assistant competencies and present and future software and technology needs of administrative professionals based on demographics in the Eau Claire region.

The correlations between administrative assistant competencies and present and future software and technology needs of administrative assistants based on demographics were examined. There were some differences in performance of competencies by administrative professionals based on demographic criteria. Depending on the size of the organization and type of business, administrative professionals may perform more financial functions, computer hardware and software responsibilities, and assume supervisory roles. Also, those working in small businesses were more likely to perform desktop publishing responsibilities.

## **Recommendations**

The results of this study present several suggestions for individuals affected by or working in this field to consider.

### **For Administrative Professionals**

Administrative professionals must be proactive about their career, keep up-to-date, and strive for continuous learning. A plan of action to accomplish this goal and to help administrative professionals get ahead and stay ahead includes:

1. The results of the study showed that almost all of the respondents participate in professional development activities and yet very few respondents were members of the IAAP. The lack of active participation in the organization associated with the profession was disturbing. Perhaps attempts are being made to professionalize the role of administrative assistants more from the organizational level rather than the individual level. Conceivably, efforts to professionalize this occupation have to come from the bottom up as well as the top down and across every level in between. Administrative professionals may get involved in organizations such as the IAAP, read professional publications, and attend conferences and seminars to enhance and maintain their skills (Miller, 1997).
2. The active pursuit of continuing education may help administrative professionals to develop awareness about advanced software and innovative technologies as indicated by the results in Tables 19, 20, and 21. Relevant educational opportunities and training may be available within the company or provided by external sources. Professionals may attend training sessions

about a variety of important job skills. Ongoing learning about business skills and trends will help administrative professionals stay professionally current and personally re-energized. Seminars or technical college courses about new or updated computer software packages and business technologies will assist administrative professionals in becoming computer software experts (IAAP On-Line). Also, through continuing education, administrative professionals demonstrate their willingness to accept expanding job responsibilities and changing job roles.

3. By acquiring industry certifications, administrative professionals demonstrate their ability to perform challenging job responsibilities and diminish the stereotype of the traditional secretary. Obtaining credentials of Certified Professional Secretary and/or Microsoft Office User Specialist offers proof of an individual's productivity, skills, and knowledge and possibly an advantage in a competitive business market for jobs and promotions (MOUS On-line).
4. Almost all of the respondents indicated that they plan and organize their own work. It is important that administrative professionals take initiative on the job and do not wait to be asked to do something (IAAP On-line). Along the same lines, administrative professionals should take an interest in continuous improvement by encouraging innovation and finding ways to offer assistance, ideas, and recommendations for new and improved processes and procedures within an organization (IAPP On-line and Miller, 1997).
5. The comprehensive listing of job competencies contained in this study confirms the willingness of administrative professionals to learn and perform beyond simple secretarial tasks. Furthermore, employers expect their administrative professionals to bring greater value to the workplace through skills beyond the traditional scope of a secretary (IAAP On-line). Getting cross-trained and learning as much as possible on the job is important as indicated by at least some participant performance of all of the competencies included in this study. For instance, administrative professionals may not regularly perform many of the financial functions in Table 10 but may be expected to complete any one of those tasks at a particular time. Consequently, the more an administrative professional knows about other job functions within an area, department, or division, the more valuable he/she is to the company (IAAP On-line).
6. Based on the review of literature which revealed the occupational transformation that occurred over the last decade and still continues today, administrative professionals must demonstrate flexibility, be willing to take on

additional responsibility, and face challenges and changes in the workplace (IAAP On-line and Miller, 1997).

7. The study showed that administrative professionals act autonomously. Participants rated the organizing and planning functions high for performance. What's more, employers expect administrative professionals to be able to make decisions independently in addition to organizing, planning, and managing their own work, schedules, and business functions such as conferences and meetings (IAAP On-line).
8. Administrative professionals often monitor supply and equipment purchases as well as maintenance agreements and schedules as indicated by the study. Therefore, it is necessary to become techno-literate (Lapp, 1997) and keep informed about available business equipment, accessible vendors, and technology trends, and how emerging technology can be used within the organization (IAAP On-line).
9. Respondents cited high levels of performance for many of the record and file management competencies. Also, administrative professionals frequently conduct research and facilitate project management from conception to completion (IAAP On-line) and thus, must be able to manage information efficiently.
10. The results of the study prove that customer service, interpersonal, and communication skills are essential. Administrative professionals must be able to communicate effectively. The IAAP (On-line) also recommends becoming the communications hub for the organization.
11. Survey respondents agreed that they train others on equipment, explain office procedures, and orient new employees; responsibilities that preserve the continuity of organizational knowledge. Many administrative professionals are taking on organizational leadership roles of training and supervision (IAAP On-line). Moreover, Lapp (1997) suggests breaking a few rules and positioning oneself to be "a key player in the loop". In other words, "successful administrative professionals will be those who demonstrate their value to the company" (McEwen, 1997).

### For Businesses and Educators

Businesses and business educators need to provide learning opportunities for administrative professionals that enhance and grow their skills. Although this study focused only on technical skills, mastery of soft business skills facilitates maximum job performance and therefore success. McEwen (1997) recommends that businesses and business education instructors promote both soft

skills and technical skills when preparing office professionals for the next century:

1. Teach strong technology skills. The study verified that administrative professionals utilize technology in almost every aspect of their job.
2. Teach teamwork skills. The largest numbers of respondents work for organizations with 51 or more employees making teamwork an essential skill. But regardless of size of the organization, responsibilities of administrative professionals typically have an effect on many people in the company.
3. Teach problem-solving skills.
4. Teach the importance of loyalty, dedication, and strong work ethic.
5. Encourage administrative professionals to familiarize themselves with the goals, policies, procedures, and the culture of the organization in order that they may work more efficiently and effectively.
6. Develop resiliency. Administrative professionals must learn to adapt and be receptive to change in the areas of job roles, software, and technology as suggested by this study.
7. Prepare administrative professionals for lifelong learning. Businesses and educational institutions should offer ongoing professional development and continuing education opportunities for administrative professionals that address the variety of skills and responsibilities encompassed in this study.

### **Related to this Study**

Business educators should also consider a few additional recommendations related to this study:

1. Initiate efforts toward professionalism of this occupation. The Chippewa Valley Technical College and other colleges within the Wisconsin Technical College System can begin a program shift that focuses on professionalism, management/supervision skills, extensive, diverse, and advanced software expertise, and innovative business technologies.
2. Determine why many of the respondents were not able to make predictions about future software and technology needs. The Business Technology Department should continue open communication with employers in the region to better determine specific software and technology needs for inclusion in the curriculum of the Administrative Assistant program.

3. The study should be replicated in a few years. Many comments suggest that this is a changing field. New technology and business and industry reorganization has resulted in changing responsibilities for the administrative professional. The study should thus be replicated in a few years to determine the changing competencies and to keep the Administrative Assistant degree program at Chippewa Valley Technical College current.
4. The study could be replicated for all Administrative Assistant degree programs within the Wisconsin Technical College System. The competencies and software and technology needs of administrative professionals may vary based on demographics within the state of Wisconsin. The study should thus be replicated statewide to determine the changing competencies and to keep all Administrative Assistant degree programs within the Wisconsin Technical College System current.
5. If the study were replicated again, more specific directions and an expanded rating scale would be needed for the survey section on future trends. The results of this study were confounding because the response category of expected future performance was outside the range of the response scale. A separate scale would allow for improved analysis in predicting future trends.

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# Pumping Demonstration: The Control of Closed Loop Systems

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## Abstract

The pumping system demonstration that was constructed displays closed loop pumping systems. It models a pumping arrangement found in a large building's heating, ventilating, and air conditioning (HVAC) system. Controlling flow rates efficiently in large systems is a common problem. Maximum capacity is rarely needed; when unnecessary, the flow must be slowed or otherwise regulated. This system allowed for testing different means of controlling flow rates. Through experimentation, measurements of flow rate, pressure, and power usage were taken for various methods of control. From this, it became clear that the use of variable frequency drives was the most efficient way to control the system's flow rates. This result was then generalized: in pumping systems the use of variable frequency drives to maintain constant pressure across the load provides for the most efficient means of operation.

## Introduction

Closed pumping systems are used in the HVAC system of a building to control the flow of hot and cold water. Flow is increased when more heating/cooling is needed and is reduced when less heating/cooling is needed. With large buildings, large pumping systems are required. These pumping systems can require a large amount of energy to operate. Consequently, increased efficiency of system control can correlate to a large savings in energy. There is cost saving as well.

The pumping demonstration that was assembled models a portion of a closed loop system that would be found in a HVAC system. This demonstration allowed for the exploration of various means to control system flow. Measurements were taken to determine the most efficient method by which system flow could be controlled. Methods examined included: a throttling (choke) valve being turned to reduce flow rates; the use of a variable frequency drive keeping a set-point pressure constant across the system's pump; and the use of a variable frequency drive keeping a set-point pressure constant across the system's load.

Prior to this experimentation, it was known that the use of a variable frequency drive with pressure across the load being kept constant should provide

for the most efficient means of controlling flow rates. The experiment sought to verify this and also provide a means to quantify the advantages of variable speed drives. With the demonstration that was built (a pumping system on a very small scale compared to that of a large building's system) it was hoped that enough energy savings could be measured with variable speed drive control to demonstrate its effectiveness.

To achieve these results, many problems needed to be understood and overcome. First, the pumping system required design and fabrication. Second, the system needed to have sensors for pressure, flow, and power consumption accurately placed in proper locations. With both of these tasks, it was important that the system be left flexible enough so that it could easily be adapted for different types of control. Third, system operation and pump curves needed to be established. To achieve this, the manufacturer's pump curves required verification and a maximum efficiency curve for the system needed to be determined. Finally, different means of controlling flow rates had to be measured and compared to the system's highest theoretical efficiency.

## Methodology

### System Design

Even though the system was very small with respect to the size of an actual HVAC system, it was complex nonetheless. Many different sections of piping were put in place to provide for different demonstrations, including the closed loop control that this project focused on. Consequently, many components were used in the completed pumping system.

The system was assembled in the Training Laboratory at Danfoss Graham in Milwaukee. There was limited space for the system as well, the design had significant size constraints. Also, due to the multitude of equipment donated to the project, many different diameters of PVC piping were required. Hence, the design included many adaptors. The pump, flow, and pressure transducers had inlet and outlet piping requirements to provide for a more laminar flow as well. Apart from such logistical considerations, the design had to be functional not only for my project but also for future uses of the project by Danfoss Graham (these are briefly discussed in Appendix E).

With such considerations in mind, the pumping system was designed. The design allows for a variety of demonstrations and lab experiments to be performed. In the heating/cooling closed loop demo, different means of controlling flow in a secondary pumping system can be compared in terms of power usage and efficiency. The pressure boost system demonstrates open loop pumping systems and allows the ability of drives to provide for more efficiency to be shown.

In addition to the demonstrations that the system was designed for, extra valves and a drain system were built in. The extra valves can be used to represent longer piping runs, a larger load, etc. The drain system was

required to prevent things from growing in stagnant water if the system was left full.

This design was then implemented, leading to the creation of a complete system. Due to thorough planning, the construction of the demonstration went smoothly.

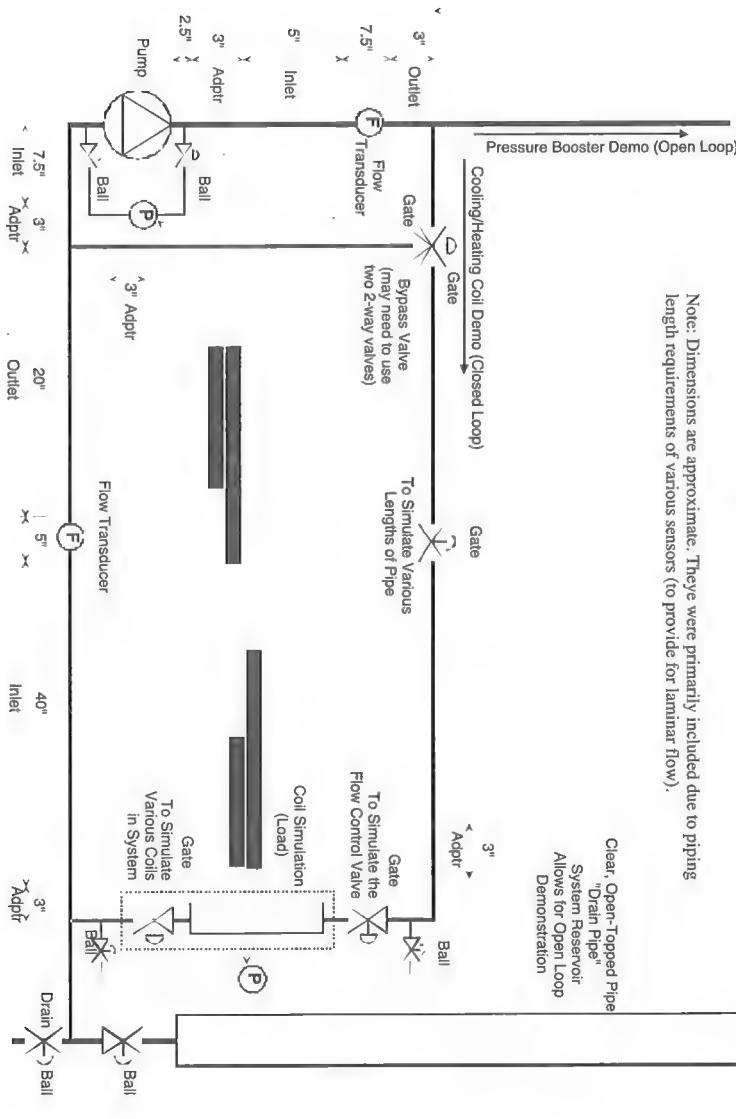
### Experimentation

From this design, the closed loop experiments could be performed. For the various tests that were run, sensors required different positioning and different setups were required. These tests will be discussed here, while the results will be discussed later.

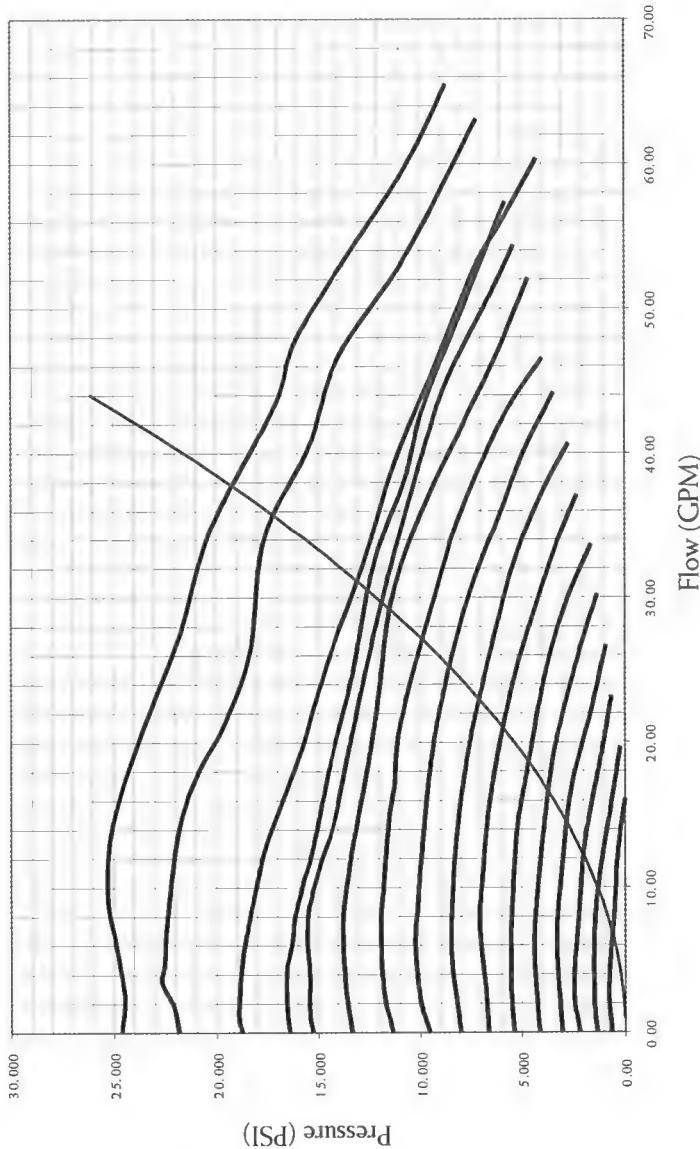
The first experiment that was performed was the determination of pump curves. These curves, which were created with the pump running at a set percentage of its maximum speed, plot pressure across the pump vs. flow rates. The pump was run at maximum speed with all valves open. At regular intervals flow was constricted (about 5 GPM less each trial) and pressure, flow, and power were measured. The pump was slowed until very few data points could be generated and flows were rather low, occurring at 25% of the maximum pump speed. From this data, pump curves could be plotted. Efficiency was also calculated at each flow rate. The points of maximum efficiency were noted, since these points are the ideal conditions that the pump should be operating at to achieve maximum power savings. Ideally, the system should be designed to allow for running near this maximum efficiency curve. In Appendix B, a sampling of the data from the pump curve experimentation is presented.

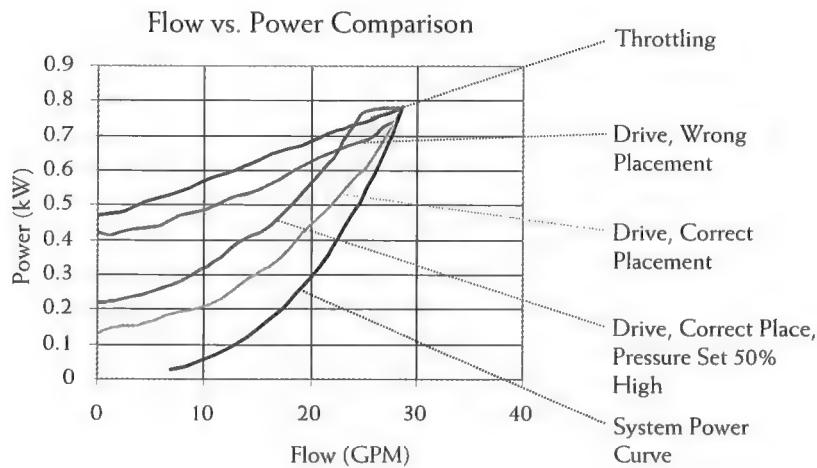
The second experiment involved finding the most efficient means to control flow in this pumping system. Four tests were conducted. In each test, flow, pressure, and power consumption were measured. First, a throttling system was simulated, where flow is reduced by closing down on a gate valve. Second, a drive was used with the pressure sensor across the pump, the wrong place to measure pressure. Placing the sensor here ignores that the pressure loss that occurs in the piping is dependant upon system flow rates. No matter the flow, in this placement the pump will still produce the needed pressure to satisfy the load at full flow conditions, when the maximum amount of pressure is lost in the piping. Hence, the drive doesn't take advantage of the variable pressure losses in the piping, leading to inefficiencies. Third, a drive was used with the pressure sensor placed across the load – the correct placement. Finally, a drive was used with the pressure sensor in the correct position, but the drive was set at a pressure 50% higher than what would be required to fulfill the needs of the load.

Note: Dimensions are approximate. They were primarily included due to piping length requirements of various sensors (to provide for laminar flow).



Experimental Pump Curves with  
Best-Fit Max Efficiency Curve





## Results

As the previous plot of power vs. flow for the different control methods indicates, the most efficient method of control of those tested is a variable frequency drive with the pressure sensor correctly applied. This verified the results that were expected with the experiment.

The energy savings of a correctly applied drive were calculated. From this, the payback time was determined, assuming that the two options were throttling control and the drive. The control system includes that was used for this includes: a VLT 6000 Drive with fuses and a MAMAC Pressure Sensor. The drive list price is \$1,410, the sensor is \$875. However, a customer commonly pays, at most, half of the list price. This totals the system cost at \$1,143. This is the same control system that was used in the experimentation.

The calculations for the energy savings can be seen in Appendix D. In short, the energy savings of the drive control system will recoup the money invested in the drive in 4.4 years.

The power savings over time could easily justify the purchase of adjustable frequency drives. In many ways, this conclusion was surprising. The pumping system built was not very large and yet the drive could save enough power in a short enough period of time to justify its application. A larger system, such as an HVAC system of an industrial building, would even provide a more attractive payback since the price per horsepower of the drive drops and the price of the sensor would become less significant. Also, with a larger system the energy savings will be a higher net amount as well, leading to higher net monetary savings as well.

## Appendix A: System Components and Acknowledgements

This project was of great interest in large part because of the many different pieces of equipment that were required, and that I would otherwise have been unable to use. I would like to thank the various people and companies that helped make the project a success.

### Pump:

ITT Bell and Gossett, Model 1536, ½ HP, 3450 RPM, 2 7/8" trimmed impeller.  
Donated by Mike Hultgren of Bornquest Incorporated.

### Flow Meters:

Onicon Flow Sensor, Model F-1111. Donated by Bowen Ierna of Onicon Incorporated. The model is a single turbine insertion flow meter. The error is  $\pm$  2% of actual flow.

Danfoss Magflow Flowmeter, Model MAG 5000. Donated by Johnnie Jensen of Danfoss Water and Wastewater. This works on a principle of electromagnetic wave distortion in fluid flows. The flow meter error is  $\pm$  0.5% of actual flow.

**Pressure Sensors:**

MAMAC Systems Pressure sensors. Two different styles were used: Model PR-264, a single point sensor, and Model PR-282, a differential pressure sensor. Supplied by Danfoss Graham.

Danfoss Pressure Transmitter, MBS 3000. Two of these were used in the system. Donated by Johnnie Jensen of Danfoss Water and Wastewater.

**Power Analyzer:**

Fluke 41B Power Harmonics Analyzer. Used for more accurate power measurements than the VLT Drive could provide. Supplied and setup by Ken Fonstad of Danfoss Graham.

**Thermometer:**

Radio Shack Digital High-Low Thermometer. Supplied by Ken Fonstad of Danfoss Graham.

**Variable Speed Drives:**

Danfoss VLT 6002. Two of these drives were employed. The drives were supplied, setup, VLT Software Dialog installed (software for PC control), and a control box from Ken Fonstad of Danfoss Graham.

**Electrically Actuated Valve:**

Hawley and Company Limited, DuroTRON Division, Model D2S-1. Donated by Mark Chudecke of Climate Sales.

**Heat Exchanger Coil:**

Donated by Mark Chudecke of Climate Sales.

**PVC Piping and Related Components:**

**Note:** A wide variety of pipe diameters were used because the donated equipment required a numerous different diameters of piping to connect up to.

Adaptors between different pipe sizes were only used when necessary.

All PVC piping stock materials were supplied by Ken Fonstad of Danfoss Graham.

3" Diameter Piping: 10' section of pipe.

2" Diameter Piping: 10' section of pipe, 3 solvent unions, 1 T, 2 threading adaptors.

1.5" Diameter Piping: 10' section of pipe, 1 solvent union, 1 threading adaptor.

1.25" Diameter Piping: 10' section of pipe, 1 solvent union, 1 threading adaptor.

1" Diameter Piping: 4 10' sections of pipe, 2 elbows, 3 solvent unions, 2 Ts, 4 threading adaptors, 4 valves

.75" Diameter Piping: 10' section of pipe, 2 couples, 6 elbows, 4 solvent unions, 4 Ts, 2 threading adaptors, 5 valves.

Adaptors: 3" diameter to 1.5" diameter. 2" diameter to .75" diameter. 2" diameter to 1.5" diameter. 2" diameter to 1" diameter. 1.5" diameter to .75" diameter. 1.25" diameter to 1" diameter. Two 1" diameter to .75" diameter.

1" Diameter Flanges: 2.

.75" Diameter Spigot: 1.

.75" Diameter Garden Hose Valve: 1.

1/8" Diameter Brass Fittings: 3 couples, 2 elbows with connectors, 7 needle valves.

Brass Adaptors: 2.25" diameter to 1/8" diameter.

Container of Pipe Cleaner and Cement: 1 each.

Leak Sealant: 1 tube.

## Appendix B: A Sampling of Pump Curve Data

| Pump Speed<br>(percent of 80 Hz) | Flow<br>(GPM) | Pressure<br>(PSI) | Power<br>(kW) | Efficiency |
|----------------------------------|---------------|-------------------|---------------|------------|
| 100%                             | 65.48         | 8.720             | 1.10          | 0.226      |
| 100%                             | 59.19         | 10.96             | 1.05          | 0.269      |
| 100%                             | 48.49         | 15.84             | 0.96          | 0.348      |
| 100%                             | 43.41         | 17.09             | 0.94          | 0.344      |
| 100%                             | 34.72         | 20.30             | 0.83          | 0.370      |
| 100%                             | 27.22         | 21.83             | 0.76          | 0.340      |
| 100%                             | 20.57         | 23.64             | 0.68          | 0.311      |
| 100%                             | 14.47         | 25.03             | 0.62          | 0.254      |
| 100%                             | 9.496         | 25.30             | 0.56          | 0.187      |
| 100%                             | 5.987         | 24.89             | 0.52          | 0.125      |
| 100%                             | 2.543         | 24.46             | 0.49          | 0.055      |
| 100%                             | 0.000         | 24.61             | 0.46          | 0.000      |
| 95%                              | 63.08         | 7.202             | 0.94          | 0.210      |
| 95%                              | 53.34         | 10.82             | 0.89          | 0.282      |
| 95%                              | 46.51         | 14.02             | 0.82          | 0.346      |
| 95%                              | 40.52         | 15.42             | 0.78          | 0.349      |
| 95%                              | 34.16         | 17.65             | 0.73          | 0.359      |
| 95%                              | 26.38         | 18.34             | 0.65          | 0.324      |
| 95%                              | 21.41         | 19.57             | 0.61          | 0.299      |
| 95%                              | 17.67         | 20.99             | 0.57          | 0.283      |
| 95%                              | 13.85         | 21.83             | 0.53          | 0.248      |
| 95%                              | 7.638         | 22.39             | 0.47          | 0.158      |
| 95%                              | 4.741         | 22.52             | 0.44          | 0.106      |
| 95%                              | 3.440         | 22.66             | 0.43          | 0.079      |
| 95%                              | 1.841         | 22.10             | 0.41          | 0.043      |
| 95%                              | 0.000         | 21.82             | 0.41          | 0.000      |

Readings were taken at pump speeds ranging from 100% of 80 Hz down to 25% of 80 Hz. Speeds were decreased by 5% for each experiment.

Efficiency was determined in this manner: Efficiency = Power Out / Power In. 1 kW = 2297 gal/min\*lb/in<sup>2</sup>, a conversion factor. Hence: Efficiency = (PSI)(GPM) / (kW)(2297).

Due to space limitations in this report, a complete list of pump curve data could not be supplied.

## **Appendix C: Data Relating to Various Methods of Control**

Table 1. Throttling Valve (Choke Valve)

| Pump Speed<br>(percent of 80 Hz) | Flow<br>(GPM) | Pressure<br>(PSI) | Power<br>(kW) | Efficiency |
|----------------------------------|---------------|-------------------|---------------|------------|
| 100%                             | 28.54         | 21.69             | 0.78          | 0.345      |
| 100%                             | 27.02         | 22.25             | 0.76          | 0.344      |
| 100%                             | 25.84         | 22.66             | 0.75          | 0.340      |
| 100%                             | 23.76         | 22.81             | 0.73          | 0.323      |
| 100%                             | 21.16         | 23.08             | 0.70          | 0.304      |
| 100%                             | 19.05         | 23.50             | 0.67          | 0.291      |
| 100%                             | 16.42         | 23.92             | 0.65          | 0.263      |
| 100%                             | 14.21         | 24.20             | 0.62          | 0.241      |
| 100%                             | 12.75         | 24.34             | 0.60          | 0.225      |
| 100%                             | 10.84         | 24.62             | 0.58          | 0.200      |
| 100%                             | 8.573         | 24.76             | 0.55          | 0.168      |
| 100%                             | 6.498         | 24.76             | 0.53          | 0.132      |
| 100%                             | 4.414         | 24.64             | 0.51          | 0.093      |
| 100%                             | 2.037         | 24.48             | 0.48          | 0.045      |
| 100%                             | 0.000         | 24.18             | 0.47          | 0.000      |

Table 2. Drive with pressure control across pump (wrong place). (Pressure is kept constant, set at 21.69 psi - the correct amount of pressure across pump to supply the load at the maximum flow rate.)

| Pump Speed<br>(percent of 80 Hz) | Flow<br>(GPM) | Pressure<br>(PSI) | Power<br>(kW) | Efficiency |
|----------------------------------|---------------|-------------------|---------------|------------|
| 100%                             | 28.54         | 21.69             | 0.78          | 0.345      |
| 100%                             | 27.02         | 22.25             | 0.76          | 0.344      |
| 100%                             | 25.84         | 22.66             | 0.75          | 0.340      |
| 100%                             | 23.76         | 22.81             | 0.73          | 0.323      |
| 100%                             | 21.16         | 23.08             | 0.70          | 0.304      |
| 100%                             | 19.05         | 23.50             | 0.67          | 0.291      |
| 100%                             | 16.42         | 23.92             | 0.65          | 0.263      |
| 100%                             | 14.21         | 24.20             | 0.62          | 0.241      |
| 100%                             | 12.75         | 24.34             | 0.60          | 0.225      |
| 100%                             | 10.84         | 24.62             | 0.58          | 0.200      |
| 100%                             | 8.573         | 24.76             | 0.55          | 0.168      |
| 100%                             | 6.498         | 24.76             | 0.53          | 0.132      |
| 100%                             | 4.414         | 24.64             | 0.51          | 0.093      |
| 100%                             | 2.037         | 24.48             | 0.48          | 0.045      |
| 100%                             | 0.000         | 24.18             | 0.47          | 0.000      |

Table 3. Drive with pressure control across main load (correct place). (Pressure is kept constant, set at 8.6 psi - measured from full flow.)

| Pump Speed<br>(percent of 80 Hz) | Flow<br>(CPM) | Pressure<br>(PSI) | Power<br>(kW) | Efficiency |
|----------------------------------|---------------|-------------------|---------------|------------|
| 100%                             | 28.71         | 8.6               | 0.79          | 0.136      |
| 93%                              | 25.68         | 8.6               | 0.63          | 0.153      |
| 88%                              | 23.29         | 8.6               | 0.55          | 0.158      |
| 84%                              | 21.55         | 8.6               | 0.49          | 0.165      |
| 79%                              | 19.23         | 8.6               | 0.42          | 0.171      |
| 75%                              | 16.70         | 8.6               | 0.334         | 0.187      |
| 71%                              | 14.19         | 8.6               | 0.289         | 0.184      |
| 68%                              | 11.72         | 8.6               | 0.232         | 0.189      |
| 65%                              | 9.474         | 8.6               | 0.205         | 0.173      |
| 64%                              | 7.589         | 8.6               | 0.192         | 0.148      |
| 62%                              | 5.383         | 8.6               | 0.169         | 0.119      |
| 61%                              | 3.554         | 8.6               | 0.154         | 0.086      |
| 61%                              | 1.276         | 8.6               | 0.150         | 0.032      |
| 60%                              | 0.000         | 8.6               | 0.131         | 0.000      |

Table 3. Drive with pressure control across main load (correct place). (Pressure is kept constant, set at 12.9 psi - 50% too high.)

| Pump Speed<br>(percent of 80 Hz) | Flow<br>(CPM) | Pressure<br>(PSI) | Power<br>(kW) |
|----------------------------------|---------------|-------------------|---------------|
| 100%                             | 28.74         | 8.740             | 0.78          |
| 100%                             | 26.72         | 10.82             | 0.78          |
| 100%                             | 24.57         | 12.9              | 0.76          |
| 96%                              | 22.63         | 12.9              | 0.66          |
| 92%                              | 20.49         | 12.9              | 0.58          |
| 89%                              | 18.19         | 12.9              | 0.50          |
| 81%                              | 15.63         | 12.9              | 0.43          |
| 81%                              | 13.83         | 12.9              | 0.401         |
| 78%                              | 10.91         | 12.9              | 0.334         |
| 76%                              | 8.742         | 12.9              | 0.298         |
| 74%                              | 6.696         | 12.9              | 0.270         |
| 73%                              | 4.172         | 12.9              | 0.242         |
| 73%                              | 1.463         | 12.9              | 0.222         |
| 73%                              | 0.000         | 12.9              | 0.220         |

## Appendix D: Energy Savings Calculations

Cost of Electricity: \$0.10 / kW-hr

| hours/year | Flow (%) | Flow (GPM) | Throttling Valve |                | Variable Speed |                |
|------------|----------|------------|------------------|----------------|----------------|----------------|
|            |          |            | Power (kW)       | Energy (kW-hr) | Power (kW)     | Energy (kW-hr) |
| 0          | 100%     | 28.0       | 0.78             | ----           | 0.78           | ----           |
| 263        | 90%      | 25.2       | 0.74             | 195            | 0.62           | 163            |
| 788        | 80%      | 22.4       | 0.71             | 559            | 0.53           | 418            |
| 1840       | 70%      | 19.6       | 0.67             | 1,233          | 0.43           | 791            |
| 2015       | 60%      | 16.8       | 0.65             | 1,310          | 0.32           | 645            |
| 2015       | 50%      | 14.0       | 0.61             | 1,229          | 0.29           | 584            |
| 1402       | 40%      | 11.2       | 0.59             | 827            | 0.24           | 336            |
| 438        | 30%      | 8.4        | 0.55             | 241            | 0.19           | 83             |
| Total:     |          |            |                  | 5,594          |                | 3,021          |

### Energy Savings Analysis

|                   |             |
|-------------------|-------------|
| Throttling Valve: | 5,594 kW-hr |
| Variable Speed:   | 3,021 kW-hr |
| Energy Savings:   | 2,573 kW-hr |
| Cost Savings:     | \$257.31    |
| Drive Cost:       | \$1,143.00  |
| Payback:          | 4.4 years   |

Note: The duty cycle (number of hours per year that the system will be operating at a given flow), comes from a common approximation used in the HVAC industry.

## Appendix E: Other Uses of the Pumping Demonstration System

As was alluded to previously, this pumping demonstration has the capability for other experimentation. Some of these possibilities will be briefly described.

The open loop part of the system, modeling pressure boost applications, has a pressure sensor mounted to it. With this, a similar experiment of determining the most efficient means to control flow through the open loop system can be performed. Again, the use of a variable frequency drive should provide for optimal control.

The closed loop system also has a bypass loop built into it. Diverting flow through a bypass loop is another way in which system flow can be controlled. This wasn't included in this experiment primarily due to difficulties in the operation of the second flow transducer (a second flow transducer is required to determine how much water flows through the bypass as opposed to how much went through the load). Since this project was completed, the problems associated with the flow transducer have been corrected and the entirety of the closed loop system is operational.

## Appendix F: Pictures

Since this project can't be seen in person, it can be difficult to envision. Consequently, a few pictures are being presented to assist in the understanding of the project.



The Heating/Cooling Demo loop slowly takes shape.



# Hospitality Students' Understanding of and Attitudes Toward Sexual Harassment in the Workplace

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Hospitality, M.S.

**Advised by Mr. Robert Davies**

## Abstract

The extent of sexual harassment in the hospitality industry has become a serious problem nation-wide. Hospitality students are one of the major forces for a future leadership role in the industry. Their current knowledge and attitudes toward sexual harassment in the workplace may affect how they deal with the issue when they become management in the future.

This study examined 185 hospitality undergraduate students regarding this issue. The study indicated that a high percentage of students can correctly identify sexual harassment behaviors. The results also indicated that most hospitality employers do have specific sexual harassment policies, but employers fail to deliver the policies and procedures effectively to the student employees. Students recommended on-campus training and education seminar could be provided to help them understand the issue better.

The results of the study could be used as a guide to modify the existing curriculum for hospitality education at all levels.

## Introduction

Sexual harassment is one of the most serious human resource management problems today. According to Equal Employment Commission's (EEOC) 1998 report, more than 15,000 sexual harassment claims were filed, up from nearly 6,900 in 1991. Amounts paid out by employers charged with sexual harassment in EEOC proceedings and actions alone exploded from \$7.1 millions in 1991 to \$49.5 million in 1997 (O'Blenes, 1997).

As one of the nation's largest employment sectors, the hospitality and tourism industry, is particularly susceptible to the problem. This is based on the long hours often at night, the pressure and the intimacy of hospitality service that makes sexual harassment a problem within the industry (Davis, 1998). The industry has been facing very high turnovers, high labor costs, and shrinking supply of workers for many years, and maintaining a well-trained workforce has become a critical issue for its success.

Hospitality education is one of the major forces for leadership roles in the industry. The students' collective understanding and individual attitude toward

sexual harassment may now protect them and their future staff from being sexual harassed. In addition, they will have to create an environment that understands and reinforces sexual harassment policies in the workplace once they become supervisors and management (Eller, 1990).

The researcher conducted an informal review with hospitality students and learned that a percentage of them had experienced or had known sexual harassment problems that occurred in the hospitality workplace. Many of these students had encountered difficulties in finding the right solutions. Education particularly must deliver that idea effectively and correctly. It is a fact that curriculum such as human resource management or leadership courses sometimes fails to provide skills that will be helpful to the hospitality management students after graduation.

As a great awareness is paid to the issue in society, the industry must train and retrain employees while hospitality educators should also be responsible for ensuring students learn about a workplace free of sexual harassment.

## **Problem Statement**

The purpose of the study is to examine hospitality major students' understanding of and attitudes toward sexual harassment in the hospitality workplace.

## **Literature Review**

It is not easy to define sexual harassment. According to Equal Employment Opportunity Commission (EEOC), their rare guidelines interpreted from Title VII of the Civil Rights Act of 1964: 1) Unwelcome sexual favors, 2) Request for sexual favors, 3) Other verbal or physical of a sexual nature that has effect on a person's work performance or creating a hostile work environment (Gilbert, Guerrier, & Guy, 1998). It was not until 1994, the significance of the U.S. Supreme Court's decision, Harris, and the subsequent related legal actions are best understood in the context of existing federal sexual harassment law (Enghagen, 1996).

Despite the growing awareness and the establishment of sexual harassment law, sexual harassment is still a big hassle in the hospitality industry. Employers are often advised to avoid liability and legal experiences of sexual harassment in the work environment by having written policies and procedures (Davis, 1998). The most important issue is the vulnerability of employees, the uncertainty and complexity of sexual harassment law, and the employer's liability with existing sexual harassment policies and procedures. It is a human resource problem that hospitality management needs to emphasize and work hard to prevent (Eller, 1990).

Sexual harassment is a problem not only in United States but also worldwide. Students may be exposed to sexual harassment situations in the family, school, or workplace. At this university, hospitality students have noted that

they do receive limited sexual harassment education or training from classes such as human resource management, organizational leadership, and women studies. As sexual harassment is part of human resource management, it becomes a topic area only briefly touched upon during class time. Another issue is that some of the classes are not required for hospitality students to graduate. If students choose not to register in any of the classes, they may never be exposed to the procedures and steps to manage sexual harassment in the workplace. If students do not enroll in their types of courses, industry will have to assume the responsibility to educate the hospitality students about the issue and the legal social and workplace procedures associated with sexual harassment.

## **Methodology**

The purpose of the study is to examine hospitality major students' understanding of sexual harassment issues in the workplace. In addition, students need to understand how sexual harassment policies and training are practiced in the hospitality workplace. Finally, it is needed to examine whether students need additional training or education before graduation.

A combination of Gutek's 1985 study of hotel employees' views toward the issue and a self-administrated questionnaire was used to survey a sample of 185 hospitality/tourism undergraduate students on campus. The survey was conducted on the first week of November, 2000. Students' participation in the study was voluntary and anonymous.

The sample was selected by a convenience methodology from eight classes. There were some students who were enrolled in two classes among the eight that were selected. These students informed the researcher about their participation and refused to complete a second survey. Therefore, it was anticipated that the chance of duplicate respondents would not be found in this study.

Some limitations have also been noted by this study: due to the low sample size, a random sample was not used in this study. Therefore, the results may not be generalized to the whole population.

## **Research Findings**

There were 89 male (48.1%) and 96 female (51.6%) hospitality undergraduate students participating in this research. Their average work experience in the industry was three years and ten months. The average companies they worked for was 2.73.

In order to identify students' understanding of sexual harassment, the researcher used part of Gutek's 1985 study to help students determine what is considered sexual harassment. It is hard to define sexual harassment and according to EEOC's definition, five items include: insulting sexual comments, complimentary sexual looks/gestures, insulting sexual looks/gestures, sexual

touching, expected sexual activity with job consequences could automatically be categorized as sexual harassment behaviors. "Expected socialization outside of work with job consequences and non-sexual touching" contain potential elements to create a hostile or offensive work environment. Table 1 below indicates the survey results:

Table 1. Is This Considered Sexual Harassment?

|   | Flow<br>(percent of 80 Hz) | Pressure<br>(ps) | Power<br>(kW) | Efficiency |
|---|----------------------------|------------------|---------------|------------|
| % | 28.54                      | 21.69            | 0.78          | 0.345      |
| % | 27.02                      | 22.25            | 0.76          | 0.344      |
| % | 25.84                      | 22.66            | 0.75          | 0.340      |
| % | 23.76                      | 22.81            | 0.73          | 0.323      |
| % | 21.16                      | 23.08            | 0.70          | 0.304      |
| % | 19.05                      | 23.50            | 0.67          | 0.291      |
| % | 16.42                      | 23.92            | 0.65          | 0.263      |
| % | 14.21                      | 24.20            | 0.62          | 0.241      |
| % | 12.75                      | 24.34            | 0.60          | 0.225      |
| % | 10.84                      | 24.62            | 0.58          | 0.200      |
| % | 8.573                      | 24.76            | 0.55          | 0.168      |
| % | 6.498                      | 24.76            | 0.53          | 0.132      |
| % | 4.414                      | 24.64            | 0.51          | 0.093      |
| % | 2.037                      | 24.48            | 0.48          | 0.045      |
| % | 0.000                      | 24.18            | 0.47          | 0.000      |

Then the researcher investigated the situation of students' workplace. The survey results indicated that 123 respondents (72.4%) had specific sexual harassment policies in the workplace. The rest 27.6% of the students replied either they did not have or they are not sure if they have specific sexual harassment policies. More than 2/3 of the respondents had received sexual harassment policies and less than 1/3 of the students had not or were unsure if they had. When asking if sexual harassment is a serious management issue in their companies, only 40% of them answered "yes" and the rest of the students replied either unsure or negatively. At table 2, the researcher also asked a hypothesized question, "If students were sexually harassed in the workplace, the reason they would not report is because..." This question found that nearly 50% of the respondents felt "uncomfortable to do so." About a quarter of the students thought "it is only a short-term job, just let it go", and another quarter of the students chose "other", which the following reasons implied:

1. They will definitely report the incidents to management or someone who can give the right direction and support;
2. They did not want to report the incidents because they did not want to be thought of as trouble-makers;
3. Few male respondents implied that they would not feel threatened or uncomfortable being sexual harassed by a female.

Table 2. Reasons Would not Report Sexual Harassment Behaviors

|                                  | Percentage |
|----------------------------------|------------|
| Do not know whom to talk to      | 5.3        |
| Do not feel comfortable to do so | 44.7       |
| Hierarchical workplace           | 3.5        |
| Short-term job                   | 20.0       |
| Other                            | 26.5       |

n=170

Finally, the researcher asked the respondents questions regarding sexual harassment education/training on campus. About 7% of them think they had received too much or a lot. Close to 35% of them think they had received enough. More than half of them think they did not have enough or they had none (table 3).

Table 3. Sexual Harassment Training/Education Received on Campus

|            | Percentage |
|------------|------------|
| Too much   | 3.2%       |
| A lot      | 3.8%       |
| Enough     | 34.6%      |
| Not enough | 20.5%      |
| None       | 37.8%      |

n=185 Mean=3.8 S.D.=1.07

At the same time, the researcher also found that more than 40% of the students thought on-campus sexual harassment training or education will reduce their chance of being sexual harassed in the workplace. About 35% of them stood neutral and less than 20% of them disagree on this. The researcher then asked them if training or education is provided on campus, would they consider taking the training or education? The results indicated that about 55% of them would consider while the rest will not.

The student also provided a study of their opinions toward sexual harassment issue in the workplace and sexual harassment education on campus. Those comments and suggestions were categorized as follows:

*Toward sexual harassment issue:*

1. Students view sexual harassment as a serious issue in the workplace and society. A number of the students agree that it would be good for them to know and understand more about the issue before they assume a career in the workplace;
2. Students suggest sexual harassment is not just something you learn about or know from someone; everyone should learn to respect other people. People should always obey the rules to decrease sexual harassment incidents;
3. Sexual harassment happens frequently in the workplace. Some people may be too sensitive to this issue but on the other hand, people should always be sensitive to fight for their security and safety within the working environment.

*Toward sexual harassment training and education on campus:*

1. Some students suggest extra training and education would be beneficial for them and their future career;
2. Students suggest that sexual harassment prevention training and education should be provided. They also indicated that a one-day class or seminar would be sufficient and efficient for them since most of them already have a high awareness of the issue.

## **Conclusion**

Sexual harassment has become not only a human resource management problem but also a social problem. This study has indicated that there are still students who are not aware of sexual harassment behaviors, in addition, the research results also indicate that not every hospitality company the students work for provides a sexual harassment free working environment. Studies have suggested that some sexual harassment behaviors could be prevented through sufficient training and education. Eller (1990) suggested that hospitality educators should use their influence to establish a standard for students. Furthermore, hospitality employers should be required to provide job opportunities with an anti-sexual harassment work environment as well. Educators must also inform students about sexual harassment to prepare them for their future career. The students who will be the future hospitality leaders and managers need to be prepared through formal education programs to allow them to understand how to protect the business, employees, and guests from emotional and financial harm.

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# The Vulnerability of Transporting Hazardous Chemicals Specific to the Semiconductor Industry

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## Abstract

This paper evaluates the vulnerability of hazardous chemical transportation to terrorist action. It specifically investigates the chemicals used by the semiconductor industry and why these chemicals may be targeted. It also suggests recommendations and poses the question for further consideration into the safeguarding procedures and practices for reducing the likelihood of terrorist action implemented by both the transportation industry and semiconductor firms.

## Introduction

In 1969, a United Nations report defined chemical warfare agents as "chemical substances, whether gaseous, liquid or solid, which might be employed because of their direct effects on man, animals, and plants" (Staten, 1997, p.5). Since that time, the hazardous nature and packaging of these agents has taken on a whole new look. With the threat of terrorism becoming more of a reality, it may be necessary to rewrite the list of chemicals that have become more commonly employed in terrorist attacks. Chemicals that have benign industrial uses, such as those used in metal cleaning or photo developing, can in theory be turned into dangerous weapons (Bjerklie, 2001). These weapons are "packaged" in the form of semitrucks and other vehicles used to transport hazardous chemicals.

The use of hazardous chemicals in terrorist attacks is a relatively new concept that results in industries and transporting firms being ill-prepared to deal with the threats (Macko, 1996). Dangerous chemicals are most vulnerable to interception while they are being transported or delivered, especially when one considers that 2.5 million Americans have commercial driver's licenses to carry fuels and other hazardous materials (Bjerklie, 2001). With thousands of shipments and deliveries of hazardous materials everyday, this represents a substantial opportunity for individuals desiring to cause intentional harm to other people or the environment, especially if such a person is willing to die in the process.

The semiconductor industry uses a variety of hazardous chemicals including ammonia, dichlorosilane, and formaldehyde in their computer chip fabrication

processes. Such chemicals are known to be toxic in nature, possessing severe fire/explosion characteristics and many are transported and stored in bulk quantities. For this reason, the semi conductor industry is vulnerable to terrorist-based activities during the transportation and delivery of these hazardous chemicals.

## Purpose

The purpose of this study was to research the vulnerability to terrorism that exists during the transportation of hazardous chemicals used in the semiconductor industry. This will provide many companies with a guide and better understanding of the unique risks involved in employing the use of hazardous chemicals.

## Methodology

The methodology proposed includes:

- Perform on-site visits to chemical transport and semiconductor manufacturing industries to assess current transporting and safeguarding procedures.
- Search and review literature of hazardous chemicals used in the semiconductor industry.
- Consult with representatives from the Department of Transportation, specific semiconductor industries, and the Semiconductor Environmental Safety and Health Association regarding laws and regulations and the application of these to specific industry sites.
- Interview experts in the field to examine the vulnerability of hazardous chemicals transport to acts of terrorism.

## Background on Terrorism

Terrorism is defined as the "Premeditated, politically motivated violence perpetrated against noncombatant targets by subnational groups or clandestine agents, usually intended to influence an audience" (Henderson, 2001, p.4). Thus, by this definition, the violent acts, which are generally inspired by political concerns, are being performed by persons not involved with any part of the government. These acts are being directed at those groups of people not posing a military threat.

Terrorism is effective for a number of reasons. One is that it is unpredictable. Its randomness creates fear in that one never knows where or when an attack will strike next. The violence, as exhibited by the September 11 attack on the World Trade Center, has an emotional impact and is intended to produce psychological effects far beyond the immediate damage. Those involved in terrorists groups are very dedicated. If suicide is part of the plan the success rate of the act rises to over 95 % (Ayers, 2001).

In the past, terrorism was a state sponsored activity. Noncombatant targets were the aim, and the more traditional chemical agents such as mustard gas,

cyanide, phosgene, sarin, soman, and tabun were used. Most of these agents are now difficult to obtain. Presently, terrorist acts are being perpetrated by groups of people acting on their own and motivated not so much for political reasons but out of sheer hatred. Civilian targets are being selected. The original bombing of the underground parking garage of the World Trade Center was intended to kill as many as 250,000 people (Gaines, 1999). Industrial agents and hazardous materials such as ammonia and chlorine are feared to be replacing the more traditional agents as they can inflict equivalent damage just as effectively. Technology and Internet access has increased the technical skills and sophistication with which terrorists are able to carry out their plans.

### Chemical Weapons as the Weapon of Choice

Toxic chemicals are stated to be "...any chemical which, through its chemical effect on living processes, may cause death, temporary loss of performance, or permanent injury to people and animals" (Staten, 1997, p.5). Chemical agents pose a threat during every phase of their existence: production, packaging, storage and delivery to the intended target. All of the locations and the places in between are at risk (Ayers, 2001, p.3). The possibility of a chemical attack is far more likely due to the availability of the chemicals necessary to construct some form of chemical weapon. The expense for such weapons is low and the technical knowledge needed to build a working chemical device is taught in every college level chemistry course (Staten, 1997). This knowledge would not even be necessary if a terrorist decided to sabotage an already existing facility or divert and breach a semi-trailer containing hazardous materials that was meant for other industrial use. Hazardous chemicals are often transported and stored in large quantities. An attack on such chemicals would cause widespread destruction to life and environment.

Another advantage is the lack of effective detection systems by anti-terrorist groups. Very few chemical weapons can reliably be detected when in use and some are virtually impossible to detect while being stored in a closed container. This lack of detection makes these agents ideal to transport and conceal due to their clandestine nature (Godber, 2001).

Chemical weapons also have a binary weapon use in that they may be stored in two precursor, less conspicuous forms. It is the combination of the two that will make them lethal. Symptoms of an attack can resemble a variety of other disorders, including stress. Other symptoms may include gastrointestinal distress, headaches, dizziness, and inattentiveness (Ayers, 2001). An attack with chemical weapons may not be obvious at first giving terrorists the opportunity to leave the scene undetected.

### Analysis of the Vulnerability of the Transportation Industry

Dangerous chemicals are most vulnerable to interception while they are being transported. Trucks are convenient for terrorists who would like to maintain a low

profile. Being a trucker would allow a terrorist to blend right in (Murphy and Thomas, 2001). There are thousands of shipments of hazardous materials everyday and millions of drivers hold commercial licenses. There is difficulty in monitoring a system this large. Lack of personnel is often an issue.

The financial impact of having to increase security and other economic factors would be felt by the trucking industry. The attack on September 11 put fear into the trucking industry because of the increase in fuel prices. There was the concern that the cost of operation would be too high and that many would lose their jobs. Attacks on the transportation industry would be an effective way for a terrorist to further attempt to cripple America's economy.

There is the concern of people obtaining or attempting to obtain multiple licenses. This would allow a person to operate in more than one state. Another is the use of fraudulent documents to obtain licenses to transport hazardous materials (Murphy and Thomas, 2001). Several persons with possible links to the hijackers in the September 11 attacks have obtained or tried to obtain commercial driver's licenses to haul hazardous chemicals (Murphy and Thomas, 2001, p.1). Background checks have not been a requirement. A check for suspension of licenses is done, however, criminal background checks were not being performed.

Security surrounding the transportation vehicles has been generally pretty relaxed. Trucks left idling and unguarded are easily stolen and would be a welcome target for a terrorist. Of special interest to the terrorist would be those trucks transporting hazardous chemicals such as process gases used in semiconductor manufacturing. Gases such as ammonia, chlorine, and silane can be transported and delivered to semiconductor manufacturing facilities in bulk using one million gram modules.

### **Analysis of the Vulnerability of the Semiconductor Industry**

Semiconductor industries use a large variety of different chemicals in their fabrication processes (Tables 1 and 2). The serious nature of these chemicals is exhibited by their hazardous properties and classifications. Combine the hazardous nature of these chemicals with the amount of chemical used and/or stored on site, there is significant potential for terrorist sabotage. An already existing facility that has all the ingredients necessary to produce the desired outcome would maintain a vulnerable position. Terrorists need only wait for conditions to be favorable and make the move.

There is a significant message that terrorists could reverberate to the world by attacking the "Brain of America" or one of the "Hearts of America's Technology". The attack on the World Trade Center was an attempt to humble and cripple America, and its economy, by attacking the soul of "Corporate America". The semiconductor industry would also be able to serve that purpose.

Semiconductor facilities are primarily located in highly populated urban areas. An attack on one of these facilities could produce mass casualties, disrupt

local and national economies, cripple public safety, and spew untold amounts of poisonous chemicals into the environment (McGinn, 2001). The gas cloud formed after an explosion may drift up to 5-10 kilometers from the immediate place of impact (OPCW Website, 1997).

## Chemicals Used in Semiconductor Fabrication

Table 1. Gases used in Fabrication (I.C. Manufacturing Process Overview, Semiconductor Environmental safety and Health Association (SESHA) Conference, 2001).

| Gas   | Hazard |
|---|--------|
| Ammonia (NH <sub>3</sub> )                            | FTC    |
| Arsenic Pentafluoride (AsF <sub>5</sub> )             | TC     |
| Argon (Ar)  | I      |
| Arsine (AsH <sub>3</sub> )                            | FT     |
| Boron Trichloride (BCl <sub>3</sub> )                 | TC     |
| Boron Trifluoride (BF <sub>3</sub> )                  | T      |
| Carbon Dioxide (CO <sub>2</sub> )                     | I      |
| Carbon Monoxide (CO)                                  | FT     |
| Carbon Tetrachloride (CCl <sub>4</sub> )              | CT     |
| Chlorine (Cl <sub>2</sub> )                           | CT     |
| Chlorine Trifluoride (ClF <sub>3</sub> )              | TCO    |
| Diborane (B <sub>2</sub> H <sub>6</sub> )             | FPT    |
| Dichlorosilane (SiH <sub>2</sub> Cl <sub>2</sub> )    | F(T) C |
| Dimethylzinc (CH <sub>3</sub> ) <sub>2</sub> Zn)      | FT     |
| Disilane (Si <sub>2</sub> H <sub>6</sub> )            | F      |
| Fluorocarbons<br>(various Freon compounds and others) | I      |
| Germane (GeH <sub>4</sub> )                           | FT     |
| Hydrogen (H <sub>2</sub> )                            | F      |
| Hydrogen Chloride (HCl)                               | TC     |
| Hydrogen Selenide (H <sub>2</sub> Se)                 | FT     |
| Hydrogen Sulfide (H <sub>2</sub> S)                   | T      |
| Nitrogen (N <sub>2</sub> )                            | I      |
| Nitrogen Trifluoride (NF <sub>3</sub> )               | T      |
| Nitrous Oxide (N <sub>2</sub> O)                      | O      |
| Oxygen (O <sub>2</sub> )                              | O      |
| Phosgene (COCl <sub>2</sub> )                         | FT     |
| Phosphine (PH <sub>3</sub> )                          | FPT    |
| Phosphorous Pentafluoride (PF <sub>5</sub> )          | TC     |
| Silane (SiH <sub>4</sub> )                            | FP     |
| Silicon Tetrachloride (SiCl <sub>4</sub> )            | TC     |
| Silicon Tetrafluoride (SiF <sub>4</sub> )             | TC     |
| Sulphur Hexafluoride (SF <sub>6</sub> )               | I      |
| Tungsten Hexafluoride (WF <sub>6</sub> )              | (T) C  |
| Xenon (Xe)  | I      |

Key for Table 1. (I.C. Overview, SESA Conference, 2001)

F-flammable

P-pyrophoric

T-toxic (T)-toxic byproducts

C-corrosive

I-inert

O-oxidizer

Table 2. Flammable and Combustible Liquids Used in Fabrication (I.C. Manufacturing Process Overview, SESHA Conference, 2001).

| Solvent Name                     | Classification |
|----------------------------------|----------------|
| Acetone                          | IB             |
| Butyl Acetate                    | IC             |
| Chlorobenzene                    | IB             |
| Developer Ethylene Glycol        | IIB            |
| Ethyl Lacate                     | IB             |
| Ethylene Glycol Monomethyl Ether | II             |
| Formaldehyde                     | IIIA           |
| HMDS (Hexamethyldisilazane)      | IC             |
| Isopropyl Alcohol                | IB             |
| Methyl Alcohol                   | IB             |
| Methyl Ethyl Ketone              | IB             |
| Methyl Isobutyl Ketone           | IB             |
| N-Methyl Pyrrolidone             | II             |
| Phenol                           | IIIA           |
| Photoresist IB                   | IC             |
| Propanol                         | IB             |
| Tetraethylorthosilicate(TEOS)    | II             |
| Toluene                          | IB             |
| 1,1,1-Trichloroethylene          | IIB            |
| 1,1,1-Trichloroethane            | IIB            |
| Trichlorobenzene                 | IIB            |
| Xylene                           | IC             |

### Important Risk Chemicals-Gases

Risk chemicals are classified according to several different criteria such as range effect, toxicity, size of production, storages and transports, and chemical stability (OPCW Website, 1997). The most important risk chemicals are the gases. Gases may have both local effects in the respiratory tract and systemic effects after inhalation. There are the common irritant gases such as chlorine, ammonia, nitrogen oxide, sulphur oxide and phosgene. These substances have relatively high toxicity when inhaled and many are produced, stored, and transported in large volumes. These chemicals cause irritation to the eyes, throat, and airways. Normal symptoms of poisoning by irritants are running eyes, coughing, a feeling of suffocation, pain when inhaling, and a feeling of general incapacitance (OPCW Website, 1997). Death by suffocation may occur as a result of pulmonary edema. Symptoms caused by poisoning from an irritant may not develop for hours, or in some cases, days after the exposure (OPCW Website, 1997). There are also the simple asphyxiants such as nitrogen, hydrogen and argon. Acute asphyxia, from the inhalation of pure asphyxiant gas, results in immediate unconsciousness, followed by death in a few minutes (Stacey, 1995, p.234). The chemical asphyxiants such as carbon monoxide, at different levels, will produce effects of headache, weakness, dizziness, nausea, vomiting, collapse, and death. Other gases which have both systemic and local effects are hydrogen, sulphide, phosphine, and formaldehyde.

## Discussion

Considering the amount of evidence presented to support that the transportation of hazardous chemicals is, in fact, a vulnerable target for terrorist actions, it is critical to investigate what these industries, both transportation and semiconductor, have implemented to safeguard these chemicals. The following is a compilation of recommendations proposed by transportation industries:

- Tighten existing procedures with heightened security and a more cautious approach.
- Employ ample numbers of personnel to ensure security procedures are adhered to.
- Scrutinize loading documents and shipping papers specifically with hazardous chemical shipments.
- Maintain consistent procedures to obtain commercial drivers licenses with written exams, driving tests, and age requirements.
- Perform background checks for criminal activity, proof of lawful residence, and current drivers license.
- Investigate suspicious behavior or activity.
- Institute a mandatory two-driver policy and an uninterrupted driving schedule.
- Never leave trucks idling or unattended.
- Install panic buttons and tracking devices in all transportation vehicles.
- Perform regular inspection and maintenance of all transportation vehicles.
- Inspect for proper application of placards.

The following is a compilation of recommendations proposed by semiconductor industries:

- Scrutinize any person entering the building or those wanting to gain access to the premises.
- Install adequate locking devices on gates and other points of entry.
- Check for breeches in security fences and provide upkeep for areas that are less frequented.
- Check transportation drivers for proper identification.
- Maintain relationships with transport companies that support adherence to stringent security precautions.
- Perform stringent background checks of workers at facilities.
- Upgrade the amount of security patrols in the vicinity of the facility.
- Ban nighttime cleaning crews
- Closely monitor all deliveries, vehicles, and manifests.
- Prepare for the event of a terrorist attack with the necessary links to government agencies.
- Redesign industrial processes, where possible, to replace hazardous chemicals with safer alternatives.

## Conclusion

The information established through the course of this paper has concluded that vulnerability exists in the transportation of hazardous chemicals specific to those of the semiconductor industry. The chemicals involved in the fabrication processes are toxic and pose a substantial threat to the surrounding population and environment. The true potential for disaster has yet to be realized. The use of such chemicals for terrorist purposes will continue to become more prevalent. The employment of stringent safeguarding techniques is necessary to reduce the likelihood that hazardous chemicals will be used for anything other than that use for which they were originally intended. As the means and methods by which terrorists carry out their activities evolves and become more sophisticated, so must the technology with which anti-terrorist groups counteract those activities. There will always be something more that can be done and the time to do it is now.

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# A Comparison of Calcium Gluconate and Zephiran for the Treatment of Dermal Hydrofluoric Acid Exposure

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## Abstract

Hydrofluoric acid (HF), an aqueous form of hydrogen fluoride (Lewis 1993), typically emits a colorless irritating gas at room temperature (Hance, Solomon, Salmon, Fall, & Cass 1997). This highly corrosive, commonly used inorganic compound readily attacks materials such as concrete, glass, natural rubber, and metal alloys containing silica (EPA Chemical Profile 1987). The Occupational Safety and Health Administration (OSHA) has set an inhalation limit for hydrofluoric acid at 3 ppm (2.5 mg/m<sup>3</sup>)(OSHA 2001).

Hydrofluoric acid is used in the semiconductor industry to etch quartz and metal, but along with being very beneficial, it also has numerous disadvantages. Epidermal contact with hydrofluoric acid causes a very corrosive and unique chemical burn. Hydrofluoric acid causes destruction of biological tissue by two methods; 1) unstable fluoride ions can penetrate tissues and bind to calcium and magnesium that can cause failure of various internal organs and 2) the hydrogen ions cause a deep corrosive chemical burn that is slow-to-heal (American Chemical Society (ACS, 1997). As a consequence, knowledge of the toxicological effects as well as treatment methods pertaining to hydrofluoric acid exposure is vital.

Numerous studies have been conducted to find effective treatments for epidermal exposure to hydrofluoric acid (References). Treatment must be initiated immediately after exposure or the threat of death is substantial (Bracken, Cuppage, McLaury, Kirmin, Klaassen, 1985). Two compounds currently accepted for treatment of exposure to hydrofluoric acid are calcium gluconate and a less-frequently utilized organic material known as Zephiran® (Dunn, MacKinnon, Knowlden, Billmaier, Derelanko, Rusch, Naas, Dahlgen, 1992). Whereas studies indicate that injection of calcium gluconate solutions can be reasonably effective at neutralizing hydrofluoric acid that has penetrated bodily tissues (Dunn, et al. 1992), Zephiran, may be more suited to topical application.

## Introduction

Health and safety issues need to be addressed prior to using chemicals in a production process. Many processes performed by the semiconductor industry

use hazardous chemicals with hydrofluoric acid being one of the most hazardous. The semiconductor industry is the third leading user of hydrofluoric acid, where it is used to etch circuit boards, glass, and silica wafers.

Hydrofluoric acid is one of the strongest inorganic acids used by this industry today (Nakanishi, Nishimoto, Arai, Abe, Kanal, Fujiyama, and Yoshida (2001).

While hydrofluoric acid is very important to the semiconductor industry, it also is very toxic to humans. Each year more than 1,000 injuries are reported in the United States stemming from exposure to hydrofluoric acid (ACS, 1997). Though some studies indicate that calcium gluconate is preferred for long-term treatment of injury from direct contact with hydrofluoric acid (Bracken, et al. 1985), other studies indicate that Zephiran® is the better choice for treating dermal burns associated with short term exposure to hydrofluoric acid (Dunn et al. 1992). The intent of this paper is to compare the use of calcium gluconate and Zephiran, for the treatment of dermal based hydrofluoric acid injury and try to identify which treatment is more effective.

## Purpose

The intent of this study is to compare the use of calcium gluconate and Zephiran Chloride for the treatment of dermal based hydrofluoric acid exposure.

## Goals of the Study

- Examine the physical implications associated with dermal-based exposure to hydrofluoric acid
- Analyze topical-based treatment methodologies for dermal hydrofluoric acid exposure as it relates to the use of Zephiran, verses calcium gluconate

## Methodology

The methodology used in the study will involve the analysis of research and literature regarding dermal hydrofluoric acid exposure. The study will review:

1. The toxicological effects of hydrofluoric acid on the human body
2. The strengths & weaknesses of dermal hydrofluoric acid exposure treatment studies/reports
3. Known treatments for dermal-based exposure to hydrofluoric acid
4. The effectiveness of calcium gluconate to Zephiran, for the topical treatment of dermal hydrofluoric acid exposure

## Toxicity of Hydrofluoric Acid

Hydrofluoric acid is known as anhydrous hydrogen fluoride, aqueous hydrogen fluoride or HF-A (National Institute for Occupational Safety and Health, 2000). It is an extremely toxic and corrosive "gas, liquid, or solid that causes visible destruction or permanent changes in human skin tissue at the site

of contact" (qtd. in National Safety Council 1988). Some unique properties of HF are shown in Table #1.

Table 1. Properties of Hydrofluoric Acid

|                       |  |                        |         |
|-----------------------|--|------------------------|---------|
| Exposure Limits:      | NIOSH REL: TWA 3 ppm (2.5 mg/m <sup>3</sup> ) C 6 ppm (5 mg/m <sup>3</sup> ) [15-minute] |                        |         |
|                       | OSHA PEL: TWA 3 ppm  |                        |         |
| Boiling Point:        | 67 °F  | 19.44 °C               | 292.4 K |
| Flammability:         | Nonflammable Gas   | Lower Explosive Limit: | N/A     |
| Vapor Pressure:       | 783 mmHg   | Upper Explosive Limit: | N/A     |
| Incompatibilities:    | Corrosive to metals. Will attack glass and concrete.                                     |                        |         |
| Target Organs:        | Eyes, skin, respiratory system, bones  |                        |         |
| Symptoms:             | Irritation eyes, skin, nose, throat; pulmonary edema; eye, skin burns; bone changes      |                        |         |
| Exposure Routes:      | Inhalation, skin absorption (liquid), ingestion (solution), skin and/or eye contact      |                        |         |
| Physical Description: | Colorless gas or fuming liquid (below 67 °F) with a strong, irritating odor.             |                        |         |

Hydrofluoric acid in gas or liquid form can cause serious respiratory damage or dermal destruction upon contact, with the possibility of causing permanent damage. This substance is often referred to as a cellular poison. Dermal overexposure can result in the formation of deep ulcers that are slow to heal.

Exposure of rats to 50 to 250 ppm hydrofluoric acid-in air for five minutes can be lethal (Hathaway, Proctor, Hughes, Fischman 1991). The estimate was based upon data from an inhalation study involving rats. Rats exposed to 166 ppm hydrofluoric acid for six hours resulted in 100% lethality (Morris & Smith 1982). Wohlslagel, Dipasqual, and Vernot (1976) found that 100% lethality occurred in rats exposed to air containing 1,765 ppm hydrofluoric acid.

For obvious reasons, human studies have not been done to establish the lethal dose for hydrofluoric acid exposure. In 1995, however, a laboratory technician splashed 100 mL of hydrofluoric acid on his lap and died fifteen days later as a result of the dermal exposure (University of Washington, 2000). Thus a 100 mL dermal exposure could be used as somewhat of a benchmark in determining the lethal dose of hydrofluoric acid.

At least two forms of injury occur following hydrofluoric acid contact with human skin or other body tissues. First to appear is a dehydration-induced coagulative necrosis that occurs soon after dermal contact. A second form of injury occurs after hydrofluoric acid enters tissues following its distribution by the circulatory system (Bracken, Cuppage, McLaury, Kirmin, Klaassen 1985). Once absorbed into tissues of the body, hydrofluoric acid rapidly forms insoluble fluoride salts that involve the binding of fluoride anions to calcium and

magnesium ions (American Chemical Society (ACS), 1997). Following the formation of calcium and magnesium fluorides is development of a liquefaction necrosis that is usually consistent with chemicals having high alkalinity, not chemicals that are acidic like hydrofluoric acid (ACS, 1997). It is because fluoride ions cause salts to form with calcium and magnesium, hydrofluoric acid tends to act more like a base than an acid (Mistry & Wainwright, 1992).

The chemical nature of hydrofluoric acid makes it difficult to halt its action, once absorbed into a tissue. Tissue destruction process may last for days (Mistry & Wainwright, 1992). Flushing of the exposed area with water is an effective method for removing surface acid, but does not stop the action of fluoride ions that have already penetrated the skin. As calcium is bound to fluoride localized areas, calcium depletion occur in the body.

If calcium depletion is observed in the blood, insufficient amounts of calcium in the body can cause hypocalcemia results. With the onset of clinical hypocalcemia, the heart function is diminished and the heartbeat becomes abnormal, which may ultimately result in cardiac arrhythmia. In addition to affecting the function of the heart, the liver and kidneys may also be damaged from hypocalcemia (ACS, 1997).

Along with its ability to bind to calcium, the fluoride ion can also bind to magnesium and cause hypomagnesemia, low magnesium levels in the blood. This abnormality can cause increased neuromuscular hyperirritability, a condition associated with uncontrollable firing of nerves and movement of muscles.

In addition to the physiological effects of hydrofluoric acid exposure noted above, some biochemical effects of an increase of fluoride ion in cells have been reported. Fluoride ion and fluoride salts are highly toxic to the body and are known to interfere with enzyme mechanisms, which makes the certain salts or the ions in them direct cellular poisons (ACS, 1997).

The process of healing from hydrofluoric acid burns is very long and painful and, in most cases, is accompanied by extensive scarring. In some situations, death has been the final result (ACS, 1997).

### Treatments for Dermal Exposure to Hydrofluoric Acid

If injury from hydrofluoric acid exposure is properly and promptly treated, the outcome can range from generally favorable to highly successful. On the other hand, improper and/or delayed treatment may result in permanent damage or death. Typical treatments for overexposure to hydrofluoric acid focus on chelating the fluoride ion to prevent further tissue destruction caused by the depletion of calcium and magnesium. As previously mentioned, speed is of the utmost importance when treating hydrofluoric acid dermal exposures.

Honeywell Inc. (previously known as Allied Signal Inc.) is the world's leading supplier of hydrofluoric acid. This company has spent a large amount of money researching practices and methods for the treatment of dermal hydrofluoric acid exposure. In a pamphlet they publish entitled, "Recommended Medical

Treatment for Hydrofluoric Acid Exposure", they recommend flushing the affected area thoroughly with large amounts of cool running water (rinsing limited to 5 minutes). As the rinsing is stopped they recommend the application of a 0.13% Zephiran, (benzalkonium chloride) solution or 2.5% calcium gluconate gel (Honeywell Inc., 1998).

DuPont is another manufacturer of hydrofluoric acid. In the material safety data sheet they have developed and distributed, it is recommended that exposed skin be thoroughly rinsed with tap water for 5 minutes and no longer since additional flushing is unnecessary and will delay the application of a topical treatment. They suggest the application of 2.5% calcium gluconate gel, although no duration is recommended (American Chemical Society, 1997).

A third supplier of hydrofluoric acid is Mallinckrodt Baker Inc. Information in their material safety data sheet advises a 15 to 20 minute water rinse followed by treatment with Hyamine 1622 (tetracaine benzethonium chloride) or 0.13% solution of Zephiran, (benzalkonium chloride). In addition to this treatment methodology, the Mallinckrodt Baker Inc. material safety data sheet also includes a note to the treating physician which states, "it has been conclusively shown that flushing the affected area with water for one minute and then massaging calcium gluconate gel into the exposed area until pain ceases is the most effective first aid treatment available" (Mallinckrodt Baker, 2001).

### Dermal Treatment Studies for HF Burns

Several studies using rats and pigs have been published concerning various treatments of injuries following dermal exposure to hydrofluoric acid as experimental subjects. While some of these studies involving optical and inhalation exposure to hydrofluoric acid indicated that calcium gluconate is effective for treatment of dermal exposure to hydrofluoric acid, other studies suggest that Zephiran® is an effective treatment for dermal exposure to hydrofluoric acid.

#### Dermal Exposure of Pigs to HF

In a study to determine the most effective treatment for dermal exposure to hydrofluoric acid, Dunn et al. (1992) evaluated topical treatments of liquid Zephiran®, 2.5 % calcium gluconate, 10 % calcium acetate soaks, iced Hyamine and 10 % calcium gluconate injections. They conducted experiments on 24 white male adolescent pigs that developed dermal burns from exposure to hydrofluoric acid. Hair was removed from the back of each pig 24 hours prior to the application of hydrofluoric acid and the pigs were anesthetized just prior to dermal exposure to 0.4 mL of 38% hydrofluoric acid at the site of the removed hair. The hydrofluoric acid was allowed to infiltrate the pigs' skin for nine, twelve, and fifteen minutes. After exposure to the hydrofluoric acid, the test areas were then rinsed with tap water for 1.5 minutes. Figure 1 on the next page depicts the histological changes to the skin of pigs exposed to the hydrofluoric acid.

Figure 1. Tissue Samples of Pig Skin Dermally Exposed to Hydrofluoric Acid

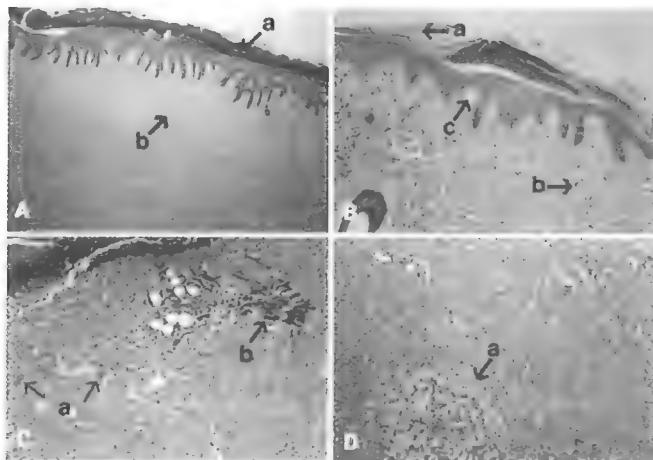


Table 2. Explanation of Histological Changes presented in Figure 1.

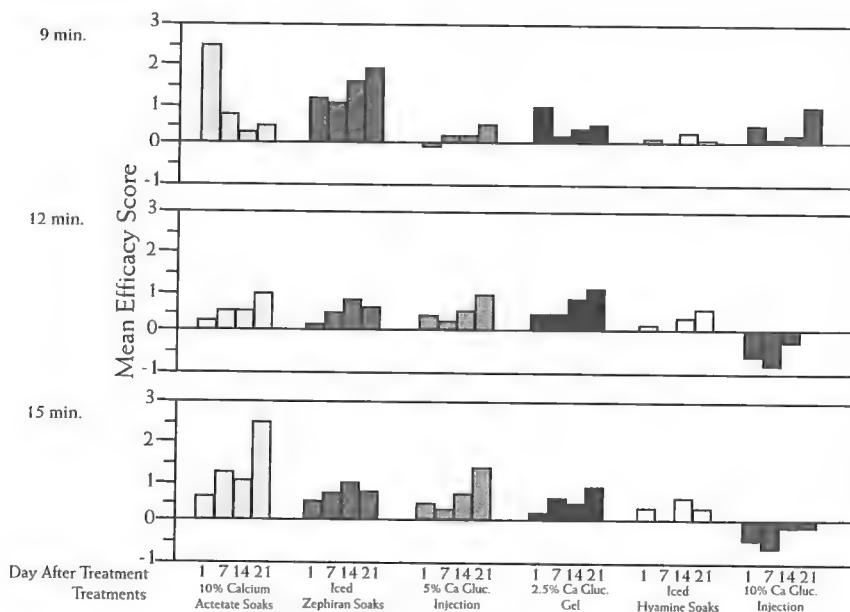
| Section | Sub Section | Explanation of Detail   |
|---------|-------------|---|
| A       | a           | Epidermal inflammation, swelling of the first layer of skin.  |
|         | b           | Dermal connective tissue necrosis, death of cells in the second layer of skin that bind tissues together.                               |
| B       | a           | Epidermal hyperkeratosis decomposing of the first layer of skin.  |
|         | b           | Sub dermal chronic inflammation, swelling in the second layer of skin.  |
|         | c           | Dermal connective tissue necrosis, death of cells in the second layer of skin that bind tissues together.                               |
| C       | a           | Sub dermal acute hemorrhage, bleeding within the deepest layer of skin.   |
|         | b           | Sub dermal mineralization, build up of bile salts in the deepest layer of skin.   |
| D       | a           | Sub dermal adipose tissue necrosis, death of fat in the form of triglycerides in the layer of skin that comes in contact with the bone. |

\*Note: From Dunn, B.J., MacKinnon, M.A., Knowlden, N.F., Billmaier, D. J., Derelanko, M.J., Rusch, G.M., Naas, D.J. Dahlgen, R.R. (1992) Hydrofluoric Acid Dermal Burns. Journal of Occupational Medicine Vol. 34, No. 9 pp 907. Permission Requested

The previous study was designed to identify the most effective treatment for dermal exposure to hydrofluoric acid using pigskin as a model. Table #3 shows the mean efficacy scores of the different treatments employed. The pig study indicated that topical application of Zephiran® is most effective for treating short-term exposure to hydrofluoric acid whereas topical application of 2.5% calcium gluconate is the most effective treatment for long-term exposure to hydrofluoric acid. Other results from these experiments suggest that ten percent calcium acetate soaks are highly effective for treating tissue damaged from a brief (< 9 minute) exposure to hydrofluoric acid. The pig studies generally demonstrated that topical treatments of hydrofluoric acid exposure were more effective than injection treatment (Dunn et al. 1992).

Table 3. Mean Efficacy Scores for HF Exposed Skin Receiving Various

HF Contact Time



\*Note: From Dunn, B.J.; MacKinnon, M.A.; Knowlden, N.E.; Billmaier, D. J.; Derelanko, M.J.; Rusch, G.M.; Naas, D.J. Dahlgren, R.R. (1992) Hydrofluoric Acid Dermal Burns. Journal of Occupational Medicine Vol. 34, No. 9 pp 905. Permission Requested

## Dermal Exposure of Rats to HF

In a study of treatments for dermal exposure to hydrofluoric acid performed on 200- to 300-gram Sprague Dawley rats, Bracken, Cuppage, McLaury, Kirmin, and Klaassen (1985) designed a set of experiments to determine what treatment is most effective for dermal exposure to hydrofluoric acid. Forty-eight hours prior to the experiments the hair on the hind legs of the rats was removed. The rats were sedated and all given similar amounts of hydrofluoric acid. These rats were then exposed to two eye drops of 70% hydrofluoric acid. After the placement of hydrofluoric acid, exposed areas were rinsed with tap water for 5 minutes. In this study Zephiran®, calcium gluconate, A+D ointment, aloe gel, and magnesium ointment were applied to the dermal hydrofluoric acid (Bracken et al. 1985).

The results of the Bracken et al. (1985) study indicate that dermal injury from the hydrofluoric acid exposure occurred instantaneously in rats. Table 4 shows the effectiveness of each treatment used in the experiment. Table 4 compares the treatment method and the surface area involved six, twenty-four, and forty-eight hours after exposure and treatment. Treatment with 2.5% calcium gluconate (CaG) resulted in a 4% decrease in the affected surface area between hour 6 and hour 24 while there was a remarkable 40% decrease in the affected surface area between the 24-hour period and the 48-hour period. Results from this study indicate that calcium gluconate is the most effective treatment in decreasing and delaying hydrofluoric acid burn development, and that Zephiran® is least effective in treating dermal exposure to hydrofluoric acid (Bracken et al. 1985).

Table 4. Effectiveness of Topical Burn Treatments at Various Periods After HF Application.

| Treatment*            | Surface Area, mm <sup>2</sup> † |                   |                   |
|-----------------------|---------------------------------|-------------------|-------------------|
|                       | 6 hr                            | 24 hr             | 48 hr             |
| HF + H <sub>2</sub> O | 267 +/- 9.6 (25)                | 254 +/- 18.4 (12) | 170 +/- 11.8 (12) |
| HF + CaG              | 161 +/- 8.0 (20)                | 154 +/- 12.7 (10) | 94 +/- 6.8 (10)   |
| HF + Zeph             | 337 +/- 15.0 (15)               | 295 +/- 40.8 (5)  | 210 +/- 25.9 (5)  |
| HF + aloe             | 247 +/- 9.8 (15)                | 226 +/- 16.9 (5)  | 128 +/- 5.5 (4)   |
| HF + A + D            | 322 +/- 19.7 (10)§              | 266 +/- 5.4 (3)   | 178 +/- 20.5 (3)  |

\*Note: From Bracken, W. M., Cuppage, F.; McLaury, R.L.; Kirmin, C., Klaassen, C.(1985) Comparative Effectiveness of Topical Treatments for Hydrofluoric Acid Burns. Journal of Occupational Medicine Vol. 27 No. 10 pp 736.  
Permission Requested

## Comparing Dermal Treatment Studies for Hydrofluoric Acid Burns

Immediate treatment of hydrofluoric acid burns in the workplace is necessary to minimize tissue damage resulting from exposure to this chemical. Bracken et al. (1985) and Dunn et al. (1992) experimented with different options for treating hydrofluoric acid dermal exposure. Experimental results reported by Dunn et al. (1992) showed that Zephiran® is the most effective treatment for short-term exposure to hydrofluoric acid, but is not as effective for long term or delayed exposure to hydrofluoric acid. The results obtained from the Bracken et al. (1985) and Dunn et al. (1992) studies suggested that calcium gluconate is by far the most effective treatment in decreasing and delaying hydrofluoric acid burns.

Making projections from animal models to humans is imperfect. A study preformed by Zhang and Monteiro-Riviere (1997) revealed that pig skin expresses integrins that are similar to those present in human skin, suggesting that pig skin is more similar to human skin and thus a better model for extrapolating the potential toxic effects of substances like hydrofluoric acid on human skin (Zhang & Monteiro-Riviere, 1997). Ritschel and Hussain determined that human skin is much less permeable than rat skin (Ritschel & Hussain, 1988).

## Conclusion

Hydrofluoric acid needs to be handled/used with extreme caution because overexposure to this chemical can lead to serious injury. Proper treatment administered in a timely manner subsequent to overexposure to hydrofluoric acid may mean the difference between life and death. Because there are many ways that overexposure to this chemical can happen, the need for proper training, as well as other protective measures, is essential to prevent or minimize injury and illness.

Studies performed by Bracken et al. (1985) and Dunn et al. (1992) indicated that calcium gluconate by far is the most effective treatment for long-term dermal exposure to hydrofluoric acid. In addition, Dunn et al. (1992) indicated that application of Zephiran® to the affected skin after flushing with water was the most effective treatment for short-term dermal exposure to hydrofluoric acid of the treatments they investigated. Because physiological properties of the skin of rats may differ from that of human skin, it is possible that Bracken's et al. (1985) study may not indicate the best treatment for humans exposed to hydrofluoric acid by skin contact. It would not only be expedient for an organization utilizing hydrofluoric acid to stock both Zephiran® and calcium gluconate in appropriate forms but also to provide training in the appropriate use of these compounds.

Future research should not only identify the best animal model for studying the effects of hydrofluoric acid on human skin but also any treatments not evaluated in previous studies. Future research should include a wide spectrum of

exposure periods and treatment methodologies prior to suggesting changes in the current recommendations for the treatment of dermal exposure to hydrofluoric acid.

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# Supercritical Carbon Dioxide as an Environmentally Sound Alternative to Photoresist Stripping Solvents

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## Abstract

The semiconductor industry is facing challenges that involve the use of photoresist stripping solvents. This literature review compares the current solvents used, namely sulfuric acid and hydrogen peroxide, to an alternative supercritical carbon dioxide-based solvent. Currently used solvents have proven to be costly in terms of money as well as the safety of workers and the environment. The information gathered demonstrates that supercritical carbon dioxide-based solvents can reduce the costs of solvent replacement and disposal, water treatment, and worker health immensely. This solvent may be a necessity for semiconductor fabs to stay competitive in the future.

## Introduction

Semiconductor industries must be able to supply the demand for luxuries we have come to expect such as computers, television, and telecommunication. To do this, they are required to use the best technology that is available (Moris, 1996). This technology usually involves using high volumes of chemicals and water since the fabrication process of wafers is primarily a series of chemical steps and processes. In fact, up to 20% of all process steps are wafer surface cleaning steps. These steps require the consumption of large quantities of chemicals and purified water (Van Zant, 2000).

The removal of photoresist is one part of the cleaning process that consumes large amounts of water and chemical solvents. The two main photoresist-stripping methods used in the semiconductor industry today are dry stripping and wet stripping (Toy, 1990; Flamm, 1992). Downfalls of conventional dry stripping methods include incomplete removal of the photoresist and damage to the wafers by the deposition of metals onto the wafer (Flamm, 1992). In addition, this method often leaves a metal ion residue behind. The removal of the residue requires an additional wet stripping step which slows down the manufacturing process and introduces a greater chance of damaging the integrity of the wafer.

Major downfalls to the wet stripping method are corrosive and toxic materials (i.e., sulfuric acid/hydrogen peroxide solution) that may incur high costs in

handling and disposal. Also, the accumulation of contaminates (i.e. heavy metals and alkali metals) in the baths can reduce their effectiveness (Livshits and Tehar-Zahav, 1997). Both of these methods have a potential of introducing hazardous chemicals to the environment and to humans. As a result, reducing the use of these solvents may greatly reduce the risks associated with the photoresist stripping process.

Although semiconductor industries have implemented stringent engineering and administrative controls to help reduce the risks associated with the chemicals in the photoresist-stripping process, employee exposure continues to be a problem (Van Zant, 2000). This risk to the employees has driven the industry to seek out alternatives to the currently used photoresist-stripping solvents. An additional driving force has been the need to reduce or eliminate toxic chemical use and waste.

Supercritical carbon dioxide-based solvents have been shown to be an excellent alternative for the photoresist stripping process. However, many facilities are continuing to use the conventional wet or dry stripping methods (Rubin, Davenhall, Barton, Taylor, and Tiefert, 1998). Facilities that continue to use conventional photoresist-stripping solvents rather than an environmentally sound alternative such as supercritical carbon dioxide are facing the danger of being exposed to environmental, human, and product loss. This study will gather information as to the effectiveness and toxicity of currently used photoresist stripping solvents and a new supercritical carbon dioxide-based solvent for use as a photoresist stripper.

## Purpose

The purpose of this study was to compare and contrast traditional photoresist stripping solvents to a new supercritical carbon dioxide-based solvent for use in the photoresist stripping process.

## Objectives

- 1.0 Examine supercritical carbon dioxide-based solvents and currently used photoresist stripping solvents.
- 1.1 Analyze the toxicity and effectiveness of currently used solvents and supercritical carbon dioxide-based solvents.
- 2.0 Analyze and evaluate currently used solvents and supercritical carbon dioxide-based solvents to establish which is the least toxic and most effective in photoresist stripping.

## Methodology

Professional literature was used to gather information regarding the toxicity, effectiveness, and cost of current photoresist stripping solvents and a new supercritical carbon dioxide-based photoresist stripping solvent. The most commonly used photoresist solvent was then compared and contrasted with

the new solvent. The criteria used to compare these two solvents were cost, toxicity, and effectiveness.

## Current Photoresist Removal Solvents

### Toxicity

The most commonly used solvent for photoresist stripping is a mixture of sulfuric acid ( $H_2SO_4$ ) and an oxidizer such as hydrogen peroxide ( $H_2O_2$ ). This solution is usually heated to a temperature of around 100°C to make it more reactive and able to remove the photoresist.

Sulfuric acid is very corrosive and is an irritant to membranes and the skin as well as a possible carcinogen (ATSDR 1999; ACGIH 2001). This acid emits highly toxic vapors when heated and has the potential of catching fire when exposed to a variety of substances including acetone and finely ground metals (ATSDR 1999). As the oxidizing component of the piranha solution, hydrogen peroxide reacts violently to a number of organic and inorganic compounds such as ethanol and sulfuric acid (NTP, 2001). Hydrogen peroxide is also an irritant to the skin and membranes causing blistering of the skin and eye injury at high concentrations (ACGIH 2001).

The main concerns facing industries employing sulfuric acid solutions in their procedures may be chronic exposure due to low-level concentrations of sulfuric acid droplets and/or gas in the air of the workplace, acute exposure to high concentrations of sulfuric acid in the air or on the skin, and the effects on the environment from ventilation exhaust and/or spills (ATSDR 1999).

### Effectiveness of Sulfuric Acid Solutions

There is a continuous push to make the architecture on wafers smaller, which is not only limited by the physics involved but possibly more by the ability to clean within such small areas. Although sulfuric acid solutions are excellent cleaning agents, they are limited in effectiveness by their physical properties. Since sulfuric acid and hydrogen peroxide are water-based, they have physical properties similar to water such as surface tension. It is this surface tension that does not allow the solution to enter small pores on the wafer for removal of photoresist (Goldfarb, dePablo, Nealey, Simons, Moreau, and Angelopoulos, 2000). The ability to clean the wafers between photoresist applications is imperative to the quality of the product since the slightest impurity may render the entire product useless. This need to remove and clean particles from such small areas is another reason to find alternative solvents with little to no surface tension.

## Supercritical Carbon Dioxide-Based Solvents

### Background on Supercritical Fluids

The study of gases under high pressures was a major topic 125 years ago and grabbed the interest of chemists from that time period (Mendelejeff, 1870). In 1879, it was found that highly compressed gases were good solvents and that their ability to dissolve substances was dependent on pressure and that the density of compressed gases can be greatly influenced by slight changes in pressure (Hannay and Hogarth 1879).

Supercritical fluid technology has been used widely in industry for extraction, purification, and chromatography processes (King, Johnson, Friedrich 1989; McHugh, Krukonis, Pratt 1994). In addition, the use of supercritical carbon dioxide has been considered as a possible alternative to the use of chlorofluorocarbons in areas that have very few environmentally benign alternatives available (Pirrota and Pava 1994; Spall 1993).

Substances have a critical temperature (TC) and pressure (PC) and the point at which the critical temperature and pressure intersect is called the critical point (CO<sub>2</sub>'s critical point is 31°C and 72.8 atm). Substances that have exceeded this point are considered to be supercritical. It is when gasses are near their critical point that they exhibit properties that are both gas-like and liquid-like (Poliakoff 2001).

Supercritical fluids are liquid-like in that they have transport and dissolving properties like a liquid and are much more dense than a gas. This gives the fluid the ability not unlike that of a light hydrocarbon (i.e., pentane) to dissolve most solutes (Poliakoff 2001). Supercritical fluids are gas-like in respect to their very low viscosity and little to no surface tension allowing them to enter the smallest area. These properties are what make supercritical fluids so attractive for cleaning, extraction, and chromatography.

### Effectiveness of Supercritical CO<sub>2</sub> as a Photoresist Stripper

There has been a lot of attention given to supercritical carbon dioxide as a resist dryer after the etching process (Namatsu, Hideo, Yamazaki, Kenji, Kurihara, and Kenji, 2000; Goldfarb, et al. 2000). This was due to photoresist collapse, caused by the surface tension created from drying the solvents used to clean the wafers. Namatsu, et al., (2000) developed a supercritical resist dryer which effectively cleans the wafer with no collapse of the photoresist. However, it was shown that at higher pressures water contaminated the inside of the chamber (Namatsu, et al., 2000). This resulted in a collapse of the photoresist due to surface tension. The problem was solved by reducing the pressure inside the chamber to just above the critical pressure of carbon dioxide, which still allowed for the attractive qualities of carbon dioxide in its supercritical state.

Although this process was shown to work effectively, it must be noted that water is not readily miscible in carbon dioxide therefore a water removal process prior to the drying stage was required (Namatsu, et al., 2000).

Goldfarb, et al (2000) found that dipping the wafer into a bath of n-hexane would remove the water, resulting in additional chemicals other than carbon dioxide needed for the process.

The use of supercritical carbon dioxide as a photoresist stripper has also been compared to ozonated water as a replacement for the acidic solvents currently used in this process (Rubin, et al. 1998). Although ozonated water is an alternative already in practice, supercritical carbon dioxide was shown to reduce water use and increase speed of removal (Rubin, et al. 1998). Rubin, et al (1998) observed that carbon dioxide alone did not affect the photoresist. This was solved by the introduction of propylene carbonate (4-methyl-1,3-dioxolan-2-one) as a co-solvent.

Propylene carbonate was first discovered as an alternative photoresist remover because of environmental concerns surrounding methylene chloride and methyl chloroform (Papathomas & Bhatt, 1996). Papathomas and Bhatt found that propylene carbonate was slightly less effective than methylene chloride at removing photoresist from printed circuit boards when the temperature was over 60°C.

One of the main attractions for the use of propylene carbonate in industry is its low toxicity to humans and the environment as shown by an extensive toxicological review (Beyer, Bergfeld, Berndt, Carlton, Hoffman, Schroeter, and Shank, 1987). However, Rubin, et al ( 1998) found that propylene carbonate alone would not affect the photoresist. In an earlier study involving a carbon dioxide and propylene carbonate solution as a supercritical fluid, it was found that a mixture of the two compounds made materials much more soluble than in either carbon dioxide or propylene carbonate alone (Page, Raynie, Goates, Lee, Dixon, and Johnston, 1991)..

Through their research, Rubin, et al (1998) developed a closed-loop system utilizing a mixture of 5% (v/v) propylene carbonate and supercritical carbon dioxide. This system was "effective in removing photoresists" and "fully compatible with commonly used metallization systems". Los Alamos refers to this process as Supercritical Carbon Dioxide Resist Remover, or SCORR. This system has been shown to be effective at removing both negative and positive photoresist that is hard baked or ion implanted to the wafer.

## Toxicity

Supercritical carbon dioxide has been termed an environmentally benign alternative to current photoresist solvents (Rubin, et al, 1998). This is true in that its reactivity and toxicity to humans is low relative to the acidic solvents being used. However, other threats are introduced into the process such as highly compressed gas. Another possible risk is the ability carbon dioxide has to displace oxygen. If there is a large leak or spill of carbon dioxide in an enclosed area such as production floor, there is a chance of asphyxiation of nearby workers.

Carbon dioxide is also a greenhouse gas that may contribute to the warming of the atmosphere. This may be a concern of facilities using this technology in the future. However, in a closed-loop system, the only carbon dioxide that enters the atmosphere is the gas that is left in the chamber when it is opened (McHugh and Krukonis 1986).

### Cost Comparison

Cost is another driving force in the search for alternative solvents in the semiconductor industry. In 1992, it was estimated that a 55-gallon drum of organic solvent, from purchase to disposal, cost about \$5,000 (Purtell, Rothman, Eldridge, and Chess, 1993). Since solvents have only a limited life-span and need to be changed frequently, this cost can add up quickly. In addition, the need to rinse the wafers after resist removal with deionized water, treatment of contaminated water after the rinse, and hazardous waste disposal fees, one can see the cost rising to great proportions. The operation cost of a deionized water system was estimated to be \$130,000 per year in 1997 (Smith and Huse 1998).

When comparing this to a supercritical carbon dioxide system, Smith and Huse (1998) showed that the cash flow needed to sustain the system after seven years of operation would be less than half of that of a system utilizing deionized water. These cost reductions can be attributed to the availability and low cost of carbon dioxide and propylene carbonate, less frequent purchasing of solvents, and the elimination of deionized water needed for the process. Also, the amount of hazardous waste that is generated is much less reducing the cost of treating and/or disposing of wastes.

### Conclusion

Supercritical carbon dioxide is just now coming to the forefront as a viable alternative to the highly corrosive solvents used for photoresist stripping. The need to reduce water use, operation cost, and toxicity to humans has been the major driving force in searching for alternatives. Supercritical carbon dioxide in a closed-loop system greatly reduces the cost of solvent disposal and purchasing while also reducing the volume of hazardous waste generated from the process. This system also removes the surface tension barrier of smaller architecture, allowing the solvent to reach and clean the smallest pores on wafers. A company willing to take a risk on developing this system and the tooling required for use within its facilities may have an edge over its competitors.

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# Low Temperature Differential Stirling Engines

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## Abstract

The objective of this research project was to examine the history and development of Stirling engines, and through the process of examination, take the concepts and fundamental characteristics of Stirling engines, and build a working model. The ultimate goal of this project was to create a reproduction of James Senft's N-92 Low Temperature Differential Stirling Engine.

## Introduction

Stirling engines have been around for a very long time. The Stirling engine (also known as the hot-air engine) was named after the creator of the first engine, constructed in 1816. Reverend Robert Stirling, who was a minister from the Church of Scotland, developed this engine with much success. The engine ran as a quarry pump continuously for two years until the main cylinder gave in due to over-exertion and metal fatigue (Rizzo, 1995). The limitations were not in the design, but in the poor quality of metal available in that time period.

Throughout the rest of the 19th century and well into the 20th century, many attempts to improve upon the original design have been made. Until recently, all of the Stirling engines that have been produced required a large temperature difference to function. A new type of engine is quickly becoming popular. This new breed of engine is known as the Low Temperature Differential Stirling Engine (LTD for short). These are engines that can operate on a temperature difference as low as  $.5^{\circ}\text{C}$  ( $100^{\circ}\text{F}$ ), although the greater the difference in temperature, the more speed and power the engine will have.

The first person to start the low temperature movement was Professor Ivo Kolin of the university of Zagreb in Croatia (Kolin, 1983). In early 1983, Kolin demonstrated his new creation to the public. The exhibit was an engine that could run on the heat of boiling water. This remarkable engine was capable of running on a temperature difference of  $15^{\circ}\text{C}$  ( $59^{\circ}\text{F}$ ) (Senft, 1996). Later, others picked up on the path that Kolin had started. Improvements to his original design have sparked the interests of many.

## Cycles

A confirmed principle of physics is that when gases are heated they expand in volume, and when allowed to cool, contract. The workings of a Stirling engine are relatively simple. The inherent cycles of operation are seen in every Stirling engine, even Low Temperature Differential Engines. These are: heating at a constant volume, expansion, cooling at a constant volume, and compression. This concept of the engine is noted as a closed cycle engine. This means that the air inside the engine never leaves the engine. In contrast, the engine found in an automobile, an internal combustion engine, incorporates the exchange of air quantities for the cycle.

The cycle of a LTD Stirling Engine is best described in An Introduction to Low Temperature Differential Engines by James Senft (Senft, 1996). Senft breaks the cycle into four distinct parts. Each cycle carries through 90° (25%) of a full crank rotation.

The first is called a transfer stroke. The displacer (a foam ring inside the engine) moves rapidly away from the heated side toward the cold side. As it moves, air is pushed out of the piston as the piston moves down to its lowest point. The air is drawn around the displacer in the direction of cold to hot. The heat is then transferred from the heated metal to the air inside the chamber. The cold air is heated. The second stroke is called the expansion stroke. The displacer moves slowly to its closest point to the cold side. The piston moves quickly though the mid-stroke. The hot air from the first stroke now fills the entire chamber around the displacer.

The next step is another transfer stroke, but this time the piston moves in the opposite direction from the first stroke. The displacer moves rapidly away from the cold side to the hot side. The heated air flows around the displacer and enters the cold section of the displacer, moving near the cold plate. Meanwhile the piston moves toward its highest point filling the chamber with the maximum volume of air.

The final stroke is known as the compression stroke. The displacer is moved to the closest position to the hot plate. The heat from the hot air is exposed to the cold side. Heat is drawn out of the air, reducing the overall volume inside the engine. The piston is once again moved quickly through the mid-stroke.

## Temperature

The way that the engine is designed allows for the output shaft to rotate either clockwise, or counter-clockwise. If a source of heat is placed under the engine, the rotation will be counter-clockwise. If a cold source is placed underneath the bottom plate, then the rotation will be reversed to the clockwise direction. Because the engine is a closed cycle engine, the source of the heat or the cooling really does not matter. The driving energy sources could be a block of ice, boiling water, the sun (if concentrated), or even a pool of liquid

nitrogen. The only stipulation is that the difference of temperature is great enough to overcome the friction generated by the motion of moving parts. The greater the change of temperature, the more the engine will react to the change in pressure inside the engine.

## Equations

At the time that the first Stirling engines were being created, physics and thermodynamics were just starting to be developed. The first person to do any work in this scientific realm was Sadi Carnot. Carnot, a French scientist, proposed: "a reversible heat engine is a perfect engine...working with whatever substance, provided only that they can be reversible, convert into work (sic) all the amount of heat supplied to them." (Rizzo, 1995). The basic concept of a Stirling engine may not be a perfect engine, but the efficiency does come closer to perfection than any other engine developed to the present day. Simply stated, the amount of energy put in the system to make the engine function is less than that required of other types of engines.

Carnot had developed one simple equation in which principles of thermodynamics could be used to calculate the thermal efficiency of the temperature difference. This is done by taking the hottest absolute temperature that the engine is subject to ( $T_h$ ), and subtracting the amount, which is required to convert the heat into work output ( $T_L$ ), then dividing that difference by the original hot temperature:

$$\text{The Carnot Thermal Efficiency} = \frac{T_h - T_L}{T_h}$$

As mentioned before, the absolute temperature (also called Kelvin temperature) must be used for the equation to work. As an example of this, if the engine could run off of the temperature difference of room temperature, which is about 21°C (294°K), and boiling water, 100°C (373°K) the calculation would be:

$$\frac{373-294}{373} = .2118$$

This produces a thermal efficiency of roughly 21%. Keep in mind that this is only the thermodynamic efficiency and the actual efficiency of the engine as a whole is acutely less due to the non-thermal deductions such as friction loss.

## Fabrication

The engine style that was chosen for this project was the N-92 Style developed by James Senft in 1992. Senft designed this engine ten years ago for NASA research (Senft, 1996). The design allows for the engine to run when

held in a hand. The temperature difference of  $1.8^{\circ}\text{C}$  ( $3^{\circ}\text{F}$ ) is enough to overcome friction and get the engine to run. The optimal temperature for operation is  $6^{\circ}\text{C}$  ( $11^{\circ}\text{F}$ ), which moves the engine at 175 rpm. A breakdown of the engine parts list can be found in Figure 2 (Bushendorf, 2002).

In the book, An Introduction to Low Temperature Differential Engines, there is a section on how to make the N-92 engine. Building required a part kit specifically designed for the model through Baily Craftsman Supply. The kit included eight nylon screws (Figure 2, item number 21), a 62-inch plastic disc for the displacer chamber ring (item 2), some O-ring materials, four Delrin bearings (19 and 22), and most importantly, a dashpot (14 and 16). The dashpot is a Pyrex glass cylinder with a graphite piston made by the Airpot Corporation (Figure 3). This took care of the parts that are difficult to make. Exotic materials such as graphite would be hard to machine. The next step was to gather the necessary stock to build the engine. The completed model can be seen in figures 1, 4, and 5.

The upper and lower plates (items 1 and 3) were made from 1/8-inch thick aluminum plate. The plates were then machined on a Bridgeport mill, using a rotary table. To maintain concentricity, the upper and lower plates were machined simultaneously. The round perimeter was cut with a ? inch end mill. Eight holes were drilled around the plate perimeter at  $45^{\circ}$  increments, used for positioning the Nylon screws. The bottom plate would later be tapped for 6-32 threads. Then the bottom plate was removed and the holes re-drilled on the top plate, providing for a clearance fit for the screws. Other through-holes were then drilled in place using the digital read out (DRO) on the Bridgeport.

The next part to be made was the displacer gland. This was turned on a lathe using 12-inch 6061-aluminum bar stock. The internal bore diameter of 1/16-inch is very critical. If the bore is too large the air will pass by the displacer shaft and the gland (item 8). This was bored very carefully with a 1/16-inch drill bit.

The displacer (item 9) itself was made from 2-inch thick high-density foam board, much like the blue foam used for insulation in the construction of houses. The foam disk was easily formed into place with the help of a belt sander. Proper thickness of .28-inch was obtained by a band saw, and cleaned off by the belt sander.

The base block (7) was machined from a block of aluminum. The only outstanding feature of the block is the counter bore on the underside. This is used for an O-ring. The rubber O-ring will keep an air-tight seal when the block is mounted onto the top plate.

The bearing plate (4) was cut out of the same piece of aluminum that the top and bottom plates came from. The bearing housing (10) and collar (11), were made from aluminum using a lathe. Other parts such as the crankpin (13), flywheel hub (15), crankshaft (17), and displacer crankpin (5), were also turned on a lathe.

The displacer rod (18) was supposed to be made out of steel, but due to limited resources the only 1/16-inch rod that was available was brass-welding rod.

One of the most difficult pieces to machine was the Displacer Chamber Ring. It was a rough-cut Plexiglas ring with an inside diameter of 6 $\frac{1}{2}$ -inches. The height of the ring had to be between .703-inch to .725-inch. An improper height would offset the volume inside the chamber. To aid in the making this piece, a template was made out of plywood. Using a Rotozip tool with a circular attachment, a path 2-inches deep was cut. The ring was then placed into the groove and sanded smooth on a belt sander. As the plastic was sanded, the excess material seemed to melt away. The ring had to be perfectly flat on the top and bottom faces, to keep air from leaking around the ring when it was sandwiched between the upper and lower plates.

The flywheel (12) was made by adhering three compact disks together with epoxy. The rods connecting the piston (14) to the right bearing assembly (19), and the displacer rod (18) to the left bearing assembly, were cut from a short length of piano wire approximately .043-inch in diameter. This material is rigid enough that it will not deform under normal usage, but easy enough to shape into the proper form using simple tools.

As an added feature, a box was produced in which to place the engine for demonstration purposes. The box is made out of 2-inch oak. The box contains a plastic bowl the same size as the engine base. Insulation was placed around the plastic bowl in the box. The insulation used was an expandable foam. The expanding foam created an efficient thermal barrier between the bowl and box. The bowl is used to contain the thermal energy source, either a block of ice or boiling water.

## Problems

The engine was fabricated over the last part of the 2001 fall semester. All of the parts were made to specification as called for on the prints. One by one, slowly, each part was made. One or two parts of the engine would be made over a week of time. In doing so, the engine parts were never fitted together. The parts were not tried together until most of the parts were completed. This created many problems when trying to assemble the engine. A few parts had to be remanufactured to different tolerances so the engine could rotate. The general idea was that once all of the parts were assembled, the engine should operate without further hold up. That thinking could not be further from the truth. The engine would not rotate under any condition. After much thought and analyzing, two major problems were found to be the cause.

The first problem was that the stroke length on the displacer was much too long. The displacer would touch the top plate when going through the cycle. The displacer must come close to the plate, but never rest on the plate. By doing so, there would not be enough room for air to expand between the

plate and the displacer. This was easily corrected by changing a hole on the end of the crankshaft. The hole was moved towards the center of the crank-shaft about .025-inch, therefore reducing the stroke length by about .05-inch. This was all the space that was needed to allow for airflow over the top of the displacer.

The second problem was more severe. There was a definite air leak somewhere in the engine. The O-rings had been placed in proper places above the top plate. This left only one place where air leakage could occur. Air was escaping rapidly around the displacer chamber ring, and the top and bottom plates. The flatness of the ring was not good enough by itself to provide a tight seal. Even tightening the nylon screws down evenly around the outside of the chamber ring did not work. This left one alternative: a silicone seal had to be used to properly seal the gap. A bead of fish tank silicone adhesive was placed on the top and the bottom of the displacer chamber ring. The silicone filled in small gaps with ease, creating an airtight seal. The air inside the chamber was now completely isolated from the air outside the engine.

After fixing these two major issues, the engine now had compression. When rolled though the cycles, a definite pressure could be felt in key positions throughout the rotation.

## **Beyond**

This type of engine may be very efficient and run on low inputs of power. Still, the fact that haunts small engines of this kind is limited output power. The output of a LTD Stirling engine is very low indeed. The output shaft rotation speed of the model never exceeds 400 rpm. The engine is capable of producing very low output energy (torque) for work. The rotation can be stopped by lightly applying pressure on each side of the flywheel. Engines such as the N-92 that have been reproduced are only good for demonstration purposes. Building a model such as this is a good way for people to see a non-conventional use of heat to run a different style of engine.

Many attempts to further the research of Stirling Engines have been made. In the mid 1970s, Ford created one of the first automobiles powered on the concept of Stirling Engines. The 1975 Ford Tornio was a joint project between Ford and Phillips to try to conserve energy and reduce emissions (Collie, 1979). After repeated attempts to fix problems such as excessive warm up time and the heater head cracking, Ford was forced to abandon the idea. Also, the emission pollutants were over the projected baseline values.

## **Learning**

There is much that can be learned from a project such as this. Many techniques that were used in the fabrication of this model were beneficial. Even the idea of carefully following directions may still leave room for error. Before this project was started, books were the only way to conceptualize the way this

engine ran. After the construction of the engine, the actual functions of each part began to fall into place. It was easier to see why each piece was needed and why it was designed in a specific way.

The engine plans did leave room for a few ways to simplify construction. One such simplification was the use of three compact disks for the flywheel instead of 1/16-inch Plexiglas. The diameter was smaller, but the flywheel was thicker, sustaining the same mass for momentum. Material such as quality Plexiglas is hard to get in small quantities, and is also very hard to shape into a round disk.

The fasteners that were used on the project were all socket head cap screws. The requirements were to have eight different diameter fasteners, with five different lengths. If this engine were to be recreated, or even differently designed, it would be in the best interest to standardize the fasteners to one or two sizes and lengths.

Although the engine is supposed to run on a temperature difference of  $1.8^{\circ}\text{C}$  ( $3^{\circ}\text{F}$ ), the actual engine required a much greater temperature difference. The friction in the engine in this article is low, but a temperature difference of roughly  $10^{\circ}\text{C}$  ( $50^{\circ}\text{F}$ ) is needed to start the engine rotating. If 12 ounces of boiling water is placed in a plastic container and placed under the engine in the insulation box the engine will run for at least 3? hours.

## Conclusions and Recommendations

After solving problems incurred with building this engine, there was a strong sense of satisfaction. The mere fact that a running engine was able to be made from a few blocks of metal is astounding. The first time that the engine started to move on its own was most exciting. Every person that has seen this engine is in complete awe. Even though the concepts have been around for a long time the word about them is still not spread.

Projects like this are a very good way for people to learn away from the classroom. This engine was not made for a class project, but instead made as a hobby. Anyone, when interested in a subject, will apply effort to get the project finished. If the project is meaningful to the person, the person will apply more time and effort in trying to learn about the subject. The main point was not just to build a working model, but to learn about the concepts at work behind the engine. By setting a goal and creating a place to start researching, it was clear that many people have done similar projects in the past, and that this is not the first.

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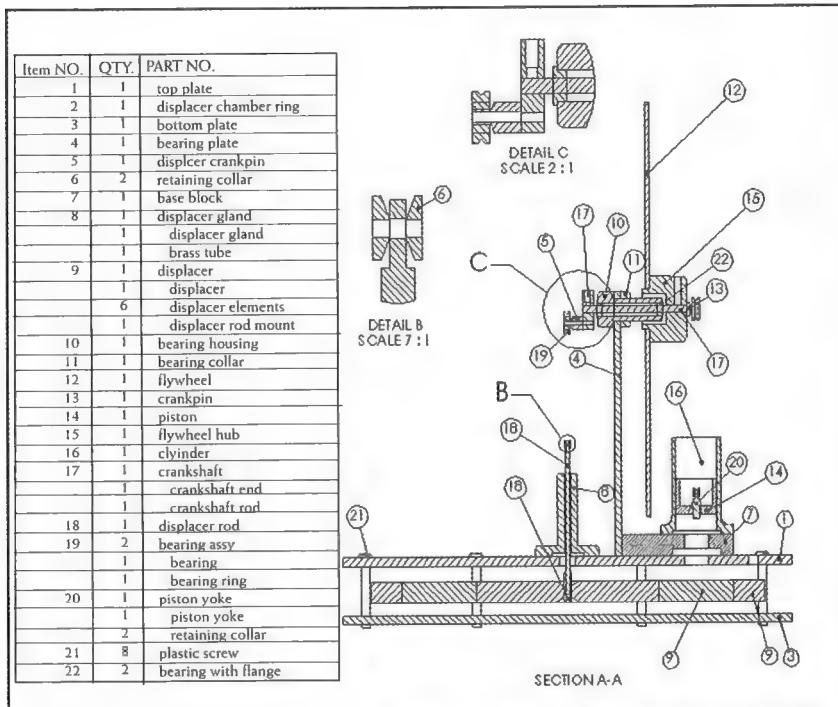
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Pictures provided Courtesy of Glenn Bushendorf based on James Senft's N-92 Engine.





# The Relationship between Perceived Organizational Justice and Organizational Citizenship Behaviors: A Review of Literature

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## Abstract

Perceived organizational justice and organizational citizenship behaviors have frequently been studied separately (e.g., Sheppard, Lewick, & Minton, 1992; Skarlicki & Folger, 1997; Allen & Rush, 1998; and Chen, Hui, & Sego 1998), as well as in conjunction with each other (e.g., Ball, Trevino, & Sims 1994; and Moorman 1991). The current review of the literature condenses the findings of these and other studies, working first with perceived justice, then with citizenship behaviors, and ending on the connection between the two areas.

## Perceived Organizational Justice

By definition, Perceived Organizational Justice (POJ) is subjective; we tend to compare our state with the state of those around us (e.g., input to output ratio, pay increases, and punishment severity). Ortiz (1999) traces justice theory back to Adams' 1965 equity theory. The equity theory states that people assign values to their inputs on a job and the outputs they receive from their job. These values are used to calculate a ratio (input to output). This ratio is then compared with the input to output ratio of a referent (someone the employee sees having similar skills, tenure, and so forth). If the ratios are equitable, there is no reason for grievances; however, this is not the case if the referent's ratio is smaller (their inputs are outweighed by their outputs). For example, if an employee's ratio was 10:10 and the referent's ratio was 15:15, the ratios are equitable; if, however, the employee's ratio was 10:10 and the referent's ratio was 10:15, the employee would feel under-rewarded (underpaid) for their inputs and would eventually adjust their inputs accordingly (reduce their inputs). If the employee's ratio was smaller than the referent's ratio (e.g., 10:15 vs. 10:10), the employee may engage in additional inputs to settle the dissonance.

Muchinsky (2000) makes the case that POJ can be differentiated into two types of justices (procedural and distributive) as well as two means, or focuses of actions (structural and social), which will be discussed later.

## Types of Justice

### Distributive Justice

Distributive justice involves the receiver's views on how their outcome compares to a referent's outcome, the outcome of another employees. Organ (1988) asserts, "Debates about the criteria—such as status, seniority, productivity, effort, and need—that should determine salary ... have to do with distributive justice" (p. 64, emphasis added). In this illustrative example, Organ alluded to the three rules of distribution, a further division of distributive justice: Equity, Equality, and Need.

Equity rule of distribution. This rule is based on the idea that rewards should be contingent upon the level of contribution. If one person works full-time, they deserve greater compensation than someone who only works part-time, if all other aspects are equal. The full-time employee would likely feel that the employer violated the equity rule if they found out that a part-time employee earned more money than they did.

Equality rule of distribution. The Equality rule states that all people, regardless of individual characteristics (such as, sex, ability, and race), should have an equal opportunity for attaining rewards. Even the briefest glance at this rule should cause alarm: people would get rewarded regardless of whether or not they do the job, let alone do it satisfactorily. Since it is ineffective to blindly reward people for random behaviors, this rule is rarely used in practice; instead, a modified version is used: rewards are based first on some important measure (e.g., ability, knowledge, production), then equally distributed. For example, if there were two supervisor openings, the CEO may choose to promote (or hire) one male and an equally qualified female. If there are several equally qualified applicants for the position, half male and half female, and the CEO chooses two women to fill the job, the rejected males would feel that the equality rule was broken.

Need rule of distribution. The final rule is rooted in the notion that less well-to-do people deserve (i.e., need) the rewards more than other, more fortunate people. For example, if all other things were equal, a single mother of two would deserve a pay increase more than someone with no children in a double income home. Should the single mother of two not get the increase, she is likely to feel that the company has broken the need rule of distribution.

### Procedural Justice

Procedural justice deals with the procedures that the organization uses to come to a decision. Organ (1988) refers to this type of justice as the way in which an organization applies the relevant criteria to arrive at a decision.

Muchinsky (2000) argued that a decision is procedurally just if it is consistent, "without personal bias, with as much accurate information as possible, and with an outcome that could be modified" (p. 277). Consider two individuals, identical in every job-relevant aspect. Suppose they were both up for their performance

review, which is the company's basis for pay increase. If one received a greater increase than the other, the recipient of the lesser would view the procedure as unjust. The recipient of the higher increase may also view the procedures as unjust, but would probably be less apt to raise any grievances.

## Means

### Structural Means

Methods that deal with the context of the interaction are said to be structural in nature. An action is structurally just if the methods used adhere to some prevailing rule of justice; for example, the three rules of distribution (Muchinsky, 2000).

### Social Means

Social methods, on the other hand, deal with how the individuals (the recipients) are treated during the action. Muchinsky (2000) states that treating people in an "open and honest fashion" exemplifies a socially just methodology (p. 279).

## Classification of Justice

With these two methods of describing justice (types and means), we can create four categories or classes of justice: Systematic, Configural, Informational, and Interpersonal. Table 1 shows a typology of the classification of these four "flavors" of justice.

Table 1. Typology of Justice Classification

| Means              |            |               |
|--------------------|------------|---------------|
| Justification Type | Structural | Social        |
| Procedural         | Systematic | Informational |
| Distributive       | Configural | Interpersonal |

## Systematic Justice

Systematic (systemic) justice is comprised of procedural justice using structural means. Muchinsky (2000) explains this concept:

*Structural means include making sure the decisions made (1) are consistent over people and time, (2) are based on accurate information, (3) represent the concerns of all parties, and (4) are compatible with prevailing moral and ethical standards (p. 279).*

## Configural Justice

Configural Justice is comprised of distributive justice using structural means. Outcomes vary with different circumstances; this is where the three rules of distribution come into play. Does the employee with the highest production get the promotion and pay increase? Or do these rewards go to the single mother of two? What about the Asian employee, who would be the only non-Caucasian to hold a position of authority?

## Informational Justice

Informational justice is the social method of achieving procedural justice. As the name suggests, there is a free flow of information. This class of justice requires that the people involved (frequently the recipients of the outcome) be given the rationale behind the decision.

## Interpersonal Justice

Interpersonal justice is the social method of achieving distributive justice. Overt concern for the outcomes of individuals typifies this class of justice.

## Organizational Citizenship Behaviors

Organizational Citizenship Behaviors (OCB) are discretionary behaviors on the part of the worker, which are neither expected nor required, and therefore cannot be formally rewarded or punished for the presence or lack of, by the organization. Schnake (1991) gives three reasons why OCB are not affected by organizational influences: (1) OCB are subtle and therefore hard to objectively rate, which makes for difficult inclusion in appraisals; (2) Some forms of OCB may pull people away from their own work to assist another; and (3) Because OCB cannot be contractually required (if they were required behaviors, they would be contractual behaviors, not OCB), the organization cannot punish employees for not performing them. For this reason, OCB is commonly defined in terms of social exchange (Moorman, 1991). Moorman describes the difference between economical and social exchange: "Because social exchange exists outside of strict contracts, the exchange tends toward ambiguity, allowing for discretionary, prosocial acts by the employee" (p. 846).

Researchers have identified many different "types" of OCB, but these are currently consolidated into five dimensions: Altruism, Courtesy, Conscientiousness, Sportsmanship, and Civic Virtue.

## Dimensions of OCB

### Altruism

The first dimension is Altruism (also referred to as helpful behaviors, prosocial behaviors, and neighborliness). This dimension is associated with behaviors that either directly or indirectly help another worker with a present work-related problem. It is easy to see the benefits for this dimension of OCB: workers helping each other instead of distracting supervisors from their jobs. Also, the workers may benefit by not showing their supervisor how often they need help, which may come up on their performance appraisal.

### Courtesy

The second OCB dimension, which is closely related to altruism, but distinctly different, is Courtesy. It refers to helpful behaviors that prevent a work related problem from occurring or help to lessen the severity of a foreseen problem. Behaviors such as advance notices, reminders, and consultation fall under this dimension.

### Conscientiousness

The third dimension is Conscientiousness, which includes such behaviors as being punctual; maintaining a better-than-average attendance record (i.e., coming to work when you're sick or during severe weather conditions); and following an organization's rules, regulations, and procedures.

### Sportsmanship

The fourth dimension is Sportsmanship; this is the only dimension that identifies a lack of behaviors. Organ (1988) described it as tolerating less-than-desirable situations without complaining or "making federal cases out of small potatoes" (p. 11). This dimension might just be a supervisor's most favorite: a lack of petty grievances.

### Civic Virtue

In the same work, Organ defined the fifth dimension, Civic Virtue, as the "responsible participation in the political life of the organization" (p. 12). An example of such behaviors is staying up-to-date with important issues of the organization.

Organ (1988) makes the note that the five dimensions of OCB may not all be present when one is found. "The people whom we think of as most conscientious are not always the most altruistic, and vice versa; and the conditions that evoke altruism from us are not always the conditions that inspire us to conscientiousness" (p. 10).

## Anti-Citizenship Behaviors

Opposite of OCB is the realm of Anti-Citizenship Behaviors (ACB). These behaviors, according to Ball et al. (1994), "detract from the work-related output of an individual" (p. 302). Behaviors included in ACB are defiance, resistance to authority, avoidance or escape from assigned work, aggression, and revenge. Burrhus F. Skinner, the behaviorist, showed that punishment on rodents would produce comparable results. Ball and associates (1994) site this reason for superiors often being "advised that punishment only be used as a last resort" (p. 316).

## Benefits of OCB

Individually, OCB are frivolous, but in aggregate, they benefit both the organization and its employees in numerous ways. To the organization go the benefits of having a group of employees who are dedicated to the company. According to Chen et al. (1998), the mere presence of OCB (specifically altruism, conscientiousness, and sportsmanship) indicated a lower turnover rate. These dedicated workers will stay with the company longer, produce more products of higher quality, and help the company succeed in many other ways. Logically we can assume that prevalent OCB will foster a better work environment within the organization. This environment, in turn, should elicit greater employee dedication, which yields greater productivity, and lowers turnover (as Chen et al. [1998] have shown).

Allen and Rush's work (1998) pointed out a benefit to the employee: performance of OCB "may produce an affective response and hence enhance a managers' liking for a subordinate" (p. 248). However, it is not known whether an employee's persistent performance of OCB causes a greater affective response by management or whether an employee who is already liked by management is noticed engaging in OCB more often than other employees (i.e., schema theory).

## Interaction of POJ and OCB

Ball et al. (1994) studied the effects of perceived unjust punishment on OCB. They used 89 supervisor-subordinate dyads, with only one supervisor to a subordinate. There was a requirement that the pair had experienced at least one instance of undesired behavior with punishment, preferably within the previous six months. If there was more than one instance of punishment, they were both asked to consider only one. Ball et al. found that when the subordinate had high POJ (i.e., control over punishment procedures and imposed punishment), they tended to engage in OCB. What's more, Ball and associates found that the subjects avoided ACB.

Skarlicki and Folger (1997) researched the revenge area of ACB, which they coined as Organizational Retaliation Behaviors (ORB). They found significant negative correlations between ORB and organizational justice (distributive [ $r=-0.44$ ] and procedural [ $r=-0.53$ ] types). They also found a significant positive

correlation ( $r = 0.69$ ) between procedural justice and what they call interactional justice (referred to as the class of interpersonal justice in the current review). This significant positive correlation suggests that procedural and interactional justices can, and do, compensate for each other. When a situation is lacking in one, a higher degree of the other may make the situation more tolerable to the employee. Therefore, they concluded that "when supervisors show adequate sensitivity and concern toward employees, treating them with dignity and respect, those employees seem somewhat willing to tolerate the combination of an unfair pay distribution and unfair procedures that would otherwise maximally contribute to retaliatory tendencies" (p. 438).

Moorman's 1991 research on POJ and OCB initially found a causal relationship between the two. But upon further analysis, the causal relationship was limited to interactional justice and OCB. This finding is supported by Skarlicki and Folgers' 1997 findings.

## Discussion

The areas of organizational justice and organizational citizenship behavior have different roots, but it is easy to see that they are not completely separate and unrelated ideas. Organizational justice is able to elicit citizenship behaviors in many cases and citizenship behaviors are the mainstay in many organizations with high organizational justice. Future research will likely clarify their common roots, but as of now, more empirical research is required.

Obviously this research is not the epitome of all there is to organizational justice and citizenship behaviors, but it is a start. With the volumes of justice theory research and the proliferation of OCB research in the 1990's, it would take years to compile a bona fide summary of the theories involved. Also with the rapid changes in the way organizations do business and the way they view their employees (for example, twenty years ago, an employee with a long list of previous jobs was looked at suspiciously, but now they are said to be experienced and may even be desirable), the theories will need to be refined.

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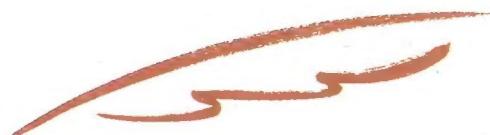
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